ILLUSTRATED
ELECTRICAL REVIEW
A Journal of Scientific and Electrical Progress.

VOL. 28. No. 17. WEEKLY.
NEW YORK, WEDNESDAY, APRIL 22, 1896.
$3 PER ANNUM. Single Copies, 10 Cents.

VIEWS, NEWS AND INTERVIEWS.

The truly gifted engineer always makes one part of his work fit into another, and no energy is ever wasted, says an exchange. A wealthy engineer who had set up a very fine place in the country, where he had carried out many pet constructive projects, was visited there by an old friend.

The visitor had so much difficulty in pushing open his front gate that he spoke about it to the proprietor.

"You ought to fix that gate," said the guest. "A man who has everything 'just so' should not have a gate that is hard to open."

"Ha!" exclaimed the engineer, "you don't understand my economy. That gate communicates with the waterworks of the house, and every person who comes through it pumps up four gallons of water."

Mr. Brayton Ives, of New York city, chairman of the Executive Committee of the Westinghouse Electric and Manufacturing Company, last week bought for $1,000 a fine park horse called "X Ray."

Walter K. Freeman, the electrical engineer who has achieved notoriety in many ways, has had another unusual experience. He is on trial in New York city for seduction, and makes his residence in the Tombs. One day last week, while taking walking exercise in one of the jail corridors, Freeman's pocket was picked of his watch. It was found in the possession of one Smith, awaiting trial for burglary. Freeman's experience brings to mind the old story of the convict in Sing Sing who couldn't find his cap. He went to Principal Keeper Connaughton and exclaimed, "Mr. Connaughton, there are thieves in this prison!"

This story of the late Sir Andrew Clark, the English physician, is told by a writer in *Cassell's Magazine*. "Two years ago the son of a wealthy nobleman lay in San Francisco suffering from typhoid fever. His friends longed to obtain the advice of the great English physician, but Sir Andrew could not be brought over in time. Nevertheless, his aid was obtained. The famous doctor went to the London end of the cable; the other end was laid into the sick room in California. Thus a consultation was held under the sea between the English medical authority and his American colleagues, the very beat of the sufferer's pulse being registered from time to time, thousands of miles away. The lad recovered."

Russia is to have an electrical branch of her army, under a lieutenant-general, two major-generals and five officers of lower grade, who will also have a military electrical school under their charge. Russian military officers have always been adept in the use of electricity.

"We don't want any X-ray jokes," said the editor of an exchange.

"Very well," said the humorist; "we will return it to the package and produce the joke about the X-ray joke. Ah, that is played out, too? Then permit me to show you my newest joke about the joke about the X-ray joke, and if that will not do I still have in reserve——."

He got the quarter.

A New Scale Wire Bridge.

The Buffalo Instrument Company, of Buffalo, N. Y., are the manufacturers of the portable scale wire bridge illustrated herewith. A general view of the instrument, which is claimed to be an entirely new departure, is given in Fig. 1. The diagram of connections is shown in Fig. 2. The bridge is contained in a mahogany case separate from the batteries. There is but one plug to the bridge, which reduces the liability of variable resistance through bad contact of plugs to a minimum.

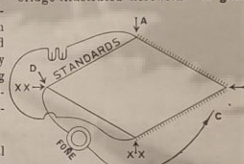


FIG. 2.—DIAGRAM OF CONNECTIONS, SCALE WIRE BRIDGE.

FIG. 1.—A NEW SCALE WIRE BRIDGE.

The variable resistance of the bridge is composed of a continuous scale wire, 500 inches in length, stretched around suitable insulated pins at the end of a table. Under the table is a chart divided into 1,000 half inches; each half inch is divided into 10 degrees, which virtually divides the scalewireinto 10,000 separate units or degrees. The chart facilitates reading the scale in making measurements.

The standards of resistance or multipliers of the bridge are 1 ohm, 10 ohms, 1,000 ohms and 10,000 ohms, respectively. The standards are calibrated to embrace one-half of the scale wire, 5,000 units or degrees of the scale (from A to B, Fig. 2), while the other side of the coils is connected to multiplier post D. The standard would be from letter B to A to D. The unknown is across the remaining leg of the diagram (from D to XX).

One side of the receiver or galvanometer is connected to D, the other side being at C, which is a finder or contact to be used in tracing the neutral point over the scale, between XX to B and A. The battery connects between points A and XX.

To find the neutral point, the finder or pointer C is drawn over the manifolds of the "scale wires." It is readily determined on which wire the neutral point lies, as the receiver indicates a sharp, loud sound, except when at the neutral point or close to it, when it becomes weaker and finally is silent at the neutral point. Readings taken with this style of receiver have proved to be fully as sensitive as with the ordinary galvanometer, and in many instances much closer results have been obtained with it. The chart under the scale wire gives the degree of the scale.

This style of instrument is so simple that no adjustment of the instrument is necessary before it is ready for use.

The Central Union Telephone Company will shortly issue $1,600,000 bonds. The company has a large floating indebtedness, and one-half of the bond issue will be used in payment to the American Bell Telephone Company in discharge of the latter company's account against the Central Union. The other $800,000 of the bonds will be offered to stockholders at 97½ on the basis of $100 in bonds for every four shares of stock.

tricity it contains in motion by some external power or force. This can only be done by or through the means of magnetism, when our energy is applied in the form of power.

The machine that is constructed for the purpose of mechanically wrapping magnetism about or around the conducting wire is called a *dynamo*

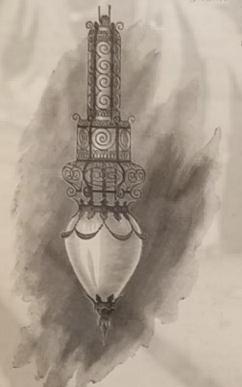


FIG. 2.—NEW KNIGHT ARC LAMP.

by the electrician, and in doing so it consumes power in the same ratio that the current is allowed to flow through the wire, plus the friction or loss in heat. The battery puts the electricity in a wire circuit in motion by means of chemical action. One of the results of chemical action is electrical pressure, and if a wire is connected to a part of a battery that is under electrical pressure, and be continued even for a great distance, any point in this wire will be found to be under electrical pressure. If this wire is returned to the battery and connected to the part of it that is negative, or has a tendency to an electrical vacuum, then a current will flow as long as the chemical action continues in the battery.

The electric current generated by the dynamo is in all respects like the current generated by a battery; that is, a continuous dynamic current is identical with a battery current. The distant telegraphic instrument then by the proper remodeling becomes a machine that will take power from a passing current, and the part that only vibrated in telegraphy is placed on axles, and revolves when a current is passing through it. The instrument in this shape is called a *motor* by the electrician.

(To be continued.)

Desires Light on X Rays—Will Some Manufacturer Kindly Answer?

TO THE EDITOR OF ELECTRICAL REVIEW:

I am desirous of obtaining a little information regarding the X rays and do not know where to apply for it except to you, as I understand that your publication is at the head of everything in the electrical line. What I wish to know is how large a spark an induction coil is obliged to give in order to successfully work a Crookes tube in experimenting with the X rays; also, if the Crookes tubes are furnished in various sizes, and how small an induction coil and Crookes tube can be used that will demonstrate that the X rays exist.

G. E. S.

Towanda, Pa., April 16.

THE DIEHL MANUFACTURING COMPANY.

IMPROVED LINE OF MANUFACTURE BY THIS PROGRESSIVE COMPANY.

Coincident with the incorporation of the Diehl Manufacturing Company, of Elizabethport, N. J., and New York, and the addition of the word "Manufacturing" to the name, a new line of handsome Knight arc lamps, in a variety of styles, and the improved Diehl dynamos and motors will be placed on the market. At the present time the company's facilities at Elizabethport are taxed to the utmost for the production of Diehl electric fans, which have been long and so favorably known that it is said more than 11,000 of the suspended fans alone are in use.

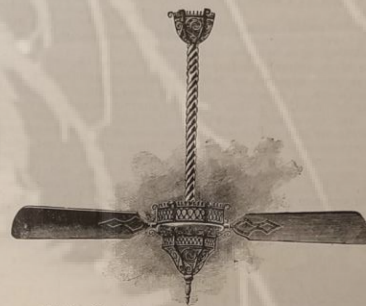


FIG. 3.—NEW DIEHL CEILING FAN, VENETIAN DESIGN.

FIG. 4.—DIEHL BALANCE WHEEL MOTOR APPLIED TO SEWING MACHINE.

Of these fans the company this year is making new and beautiful designs in venetian, polished brass and nickel and variously ornamented styles, the important feature being, moreover, that a material decrease in the amount of power required has been made. The self-oiling motors in these fans are directly coupled to the fan shafts and operate on any direct-current circuit or work successfully in series on arc and street railway circuits.

The illustration, Fig. 1, is a reproduction from a photograph of a Diehl dynamo directly connected to a Case engine. This installation is on board the steam yacht "Reverie," owned by the president of the Singer Manufacturing Company.

These machines have the armature encircling and revolving around the field magnets, which results in high efficiency, great durability and slow speed, avoiding the method of countershafting and the loss of power it incurs. This slower speed, being due to the large diameter of the armature, is obtained without increase of weight and gives a starting torque proportionately great, at the same time increasing the efficiency by a diminution of friction of the bearings and the brushes. The motors are fitted with self-aligning and self-oiling bearings and approved brush-holders, thereby requiring a minimum of attention.

The illustration, Fig. 2, of the new Knight arc lamp hardly does justice to the elaborate line which the Diehl company are preparing, and for the outdoor lamp the company has perfected a design which will be water-proof without the use of a hood. The important feature which will recommend the Knight lamp is that the striking magnet is composed of a few turns of heavy wire placed in the main circuit, and, when the current is on, this magnet is energized and pulls down the core of the shunt armature, holding the core in this position until it is weakened by the lengthening arc, then the core of the shunt magnet is released and it goes up to the feeding point. The armature is then practically out-field of the striking magnet and the arc depends entirely on the shunt magnets for regulation. This avoids the defect usual in the shunt lamp of not striking a proper arc when current is turned on. The adjustable chuck carbon-holders take in any size of carbon from one-fourth of an inch to five-eighths of an inch in diameter. The clutch wheel is used, requiring no dashpot nor main magnets. The clutch is applied to the periphery of the wheel; therefore the rod is less liable to stick when dirty than in a lamp with clutch working directly on the rod.

Since the incorporation of the company these officers have been elected: E. H. Bennett, Jr., president; Philip Diehl, vice-president; H. S. Miller, secretary, and J. A. Reid, treasurer. John C. Knight, prominently known in connection with the arc lamp industry, will superintend the lamp making. The New York office will be at 561 Broadway, under the management of C. A. Bramhall.

M. T. Lindenburg will be in charge of the Boston branch, at 128 Essex street.

President Bennett informed a representative of the ELECTRICAL REVIEW that the company were now increasing their facilities by the installation of many thousand dollars worth of new machinery, and it is fair to presume that the Diehl Manufacturing Company will, in the near future, be in the front rank as a manufacturing company.

The illustration, Fig. 4, shows the balance-wheel motor, as applied to the shaft of sewing machines. The motor is self-contained and the field magnets are attached to the shaft of the machine for connection with the current. The armature carrier acts as a balance wheel and is secured to the shaft by the clamp-stock motion. The speed is manipulated by a small brake and rheostat operated by treadle.

Safety Insulated Wire and Cable Company.

The Safety Insulated Wire and Cable Company, of New York city, last week closed a contract amounting to about $125,000, to furnish all the underground cables required by the Boston, Mass., Electric Light Company during the current year. This is a renewal of a similar contract made in 1895, which was obtained on the strength of the showing made by Safety cables in 1894.

A NEW METHOD OF STUDYING THE LIGHT OF ALTERNATING ARC LAMPS.

READ BEFORE THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, NEW YORK, MARCH 25, 1896, BY WILLIAM L. PUFFER.

(*Concluded from page 192.*)

Early in November last the subject was again taken up, with the very efficient aid of Mr. R. R. Lawrence, a post-graduate student in electrical engineering at the Massachusetts Institute of Technology, and rapidly developed with such beautiful results that it was decided to exhibit publicly before the Society of Arts, which was done some little while after, at the regular meeting of January 2, 1896.

We first attempted to take a set of instantaneous photographs of the arc at different periods of an alternation, and by the use of a pneumatic shutter, and a progressive motion of the lens, obtained some very sharply defined pictures. After many trials, this was given up, because of the practical impossibility of timing the exposures with respect to the alternations, and we decided to use a disk with half as many slots as there were pole-pieces on the dynamo, and to drive it by the shaft of the machine itself.

The dynamo available was one giving a three-phase, 500-volt current with a frequency of about 60 cycles. Two wires only were used to give us the current required.

A somewhat long, light shaft, carrying at one end the disk, and at the other a positive mechanical clutch, was mounted in line with the armature shaft. As the clutch could only be thrown in when the two shafts were nearly equal in speed, a small motor was placed so as to bring the disk up to speed when the clutch was thrown in and the motor belt removed.

The disk was held in place by a frictional clamp disk on the shaft. A graduation and reference mark served to measure angular change of disk on shaft, and therefore of slots with reference to the pole-pieces or alternation of the current.

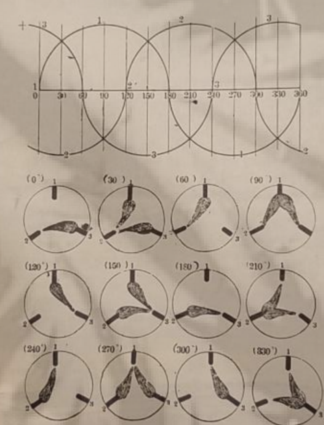
The arc to be tested was put in a boxing to keep away air from the currents close behind the disk, and a camera with a roll-holder in front of the disk. With this arrangement the arc as seen was perfectly steady at any part of the wave that corresponded to the position of the disk on the shaft, and, as the process of stopping, setting, and starting the disk was very rapid, the roll-holder being in meantime turned, many pictures could be taken in a very few minutes.

Generally, it was not necessary to take more than 12 exposures in order to get a series showing clearly the changes in light intensities during a single phase.

We found that it was about as instructive to watch the appearance of the arc on the ground glass of the camera, and far more beautiful. In this way we examined both the effect produced in the arc by change in the voltage of the circuit, the current being kept constant by alteration of the resistance.

For example, with 500 volts, and a large non-inductive resistance in series with the arc, it was plainly evident that the current wave was approximately sinusoidal, as the time of extinction of the current, as indicated by the blue band of the arc proper, was very short, and the rise and fall of the current gradual and with no irregularities. This is to be expected, as the back electro-motive force of the arc is small compared to the voltage of the generator, and the circuit as a whole is non-inductive.

The opposite condition was realized by using a lower electro-motive force and regulating by a reactive coil. The time of no current was longer, and the current appeared to jump to its maximum in an exceedingly small angular time. In this case the arc was not steady, showing clearly to the eye that the succeeding waves of current were not alike either in form or current value, and also that the angle of lag was constantly changing. This fact has always prevented an accurate plotting of wave forms by the instantaneous contact



A NEW METHOD OF STUDYING THE LIGHT OF ALTERNATING ARC LAMPS.

method, and although known to exist, was never before actually seen.

A very pretty double arc was arranged by using three carbons and wiring two circuits, each with current regulators, in such a way that the arc was the common junction, and one carbon was of one polarity, while the other two were of opposite polarity. With wire resistances in each side, there was nothing peculiar to be noted other than the effects of the junction of two currents, but when the resistance in one circuit was gradually cut out, and equivalent inductance cut in, there was at once visible evidence of the lag of the current, together with the change of shape of the wave and the unsteadiness before noted. Owing to the long time of no current in the inductive side, there were times when, even with considerable lag, there were actually no visible traces of current between either points. This effect was dependent on adjustment of current strength and inductance as well as voltage. The sequence of currents and polarity in this arc was most beautifully brought out when the disk was disengaged from the shaft, and driven by the little motor at a rate very slightly less than the dynamo.

We found that work in the immediate vicinity of the dynamo was not very desirable, owing to air currents and excessive vibration, so we arranged a combination of motors that will produce at any distance from the dynamo all the desired results.

A very nicely balanced brass disk with four radial slots in it was attached to the armature shaft of a Holtzer-Cabot synchronous induction motor of eight poles. The pulley of this motor could be driven by a light belt from a self-starting induction motor of the same make, which is, however, not quite synchronous under load. By trial the two pulleys are wound with rubber tape until their ratio is such that the brass disk will be uniformly driven at a speed a trifle above synchronism, and the arc light can be seen through the slots to pass through the alternation at a desirable rate.

By a single movement of a switch the non-synchronous motor is cut out, and the synchronous cut into circuit when the armature drops into step with the dynamo, and the arc is instantly seen as fixed; the belt is thrown off or left on, as desired. These armatures may be on the same shaft, if necessary. The synchronous motor does not stand on its base, but rests on the turned outside of its bearings in pillow blocks, which are attached to a suitable base frame.

Concentric with the shaft and firmly attached to the motor is a brass gear, six inches in diameter, and on it a graduated circle. On a lever pivoted so as to be thrown to or from the motor gear is a small spur gear with a milled head for turning.

Turning this head will evidently cause the motor to slowly rotate about its axle, and as the armature must be in step with the dynamo, and, as the turning of the motor changes the position of a given pole-piece relatively to the arc light, it follows that any part of the alternation of current in the arc may be seen on the screen, and as the motor has eight poles, a quarter turn or 90 degrees on the graduated circle corresponds to a complete cycle in the arc.

The picture of the arc can then be photographed, measured, or in any way studied at leisure in any phase relation, as, for example, when the top carbon is positive, or when there is no arc at all and only dull red carbon points visible.

In this way we have seen single arcs of high and low electro-motive force, long and short double arcs, arcs with much inductance in circuit, Jablochkoff candles, arc between a ring and a point within, the spinning arc between the ends of a carbon cylinder and a concentric carbon within, with a magnetizing coil around the inner carbon and the like.

One of the most beautiful arcs investigated by us visually and photographically was a rotary arc made by the use of three carbons in the same plane, at angles of 120 degrees apart and wired up as the junction point of an external Y load on a 500-volt, 60 cycle, three-phase generator. Non-inductive resistance was used in the circuit, and the current used in one leg of the Y was 10 or 15 amperes.

Twelve photographs were taken at equal intervals of 30 degrees in an alternation of the current in one wire. Fig. 1 shows very clearly the relation of the current waves from the different carbon points, and the curved, fan-shaped figure indicates the position and direction of the bluish arc at the corresponding angle. The base of the fan rests on a positive carbon, which has a white-hot crater and all the appearance of the positive carbon of a direct-current arc, while the tip of the fan rests on the white spot at the end of a negative carbon.

It will be seen at 0 degrees, for example, that there is no current on carbon 1 and that 2 is negative and 3 positive, the blue, fan-like arc curving from 3 to 2; 30 degrees later, 2 is still negative and 3 positive, but that an equal arc is now playing from 1 to 2. At 60 degrees 2 is still negative, 1 positive, but there is no current on 3. At 90 degrees the appearance is somewhat like 30 degrees, except that the signs are changed, and the point with the double current is necessarily much whiter, it being now positive. And so on through the changes of the complete wave.

This three-phase arc, when seen while the disk is running non-synchronously, is the most beautiful of any studied, and may be seen according to the different length of arc and the divergence of the disk from exact synchronism, either as a band of blue light, which seems to be progressively traveling over the three sides of a triangular path, or as a rapidly spinning star of blue light, being in fact a rotary arc.

The three phase arc is less noisy than the single-phase, and its light is steadier and has less variation in its total intensity, owing to the fact that the current never stops, and there is always a positive carbon. Three-cored carbons, placed parallel side by side, with slight magnetizing coils to keep the arc at the ends of the carbon, will give a very satisfactory light in the direction away from the tips, and may be used when it is desirable to throw all the light in one direction.

Four carbons, at 90 degrees apart, each with a suitable resistance in series with it, and connected to quarter-phase tap wires on a Gramme ring or other generator giving quarter-phase circuits, will also produce a rotary field arc of great beauty and interest.

Study of these arcs is still going on at the Institute of Technology under my immediate charge, which will, I hope, produce results sufficiently interesting to justify a second paper at some later date.

McClure's Magazine for May will have an article by the eminent surgeon, Dr. W. W. Keen, indicating the uses already possible, as well as those likely to become possible soon, of the Roentgen rays in the study and cure of human deformities, injuries, and diseases. The article will be fully illustrated from photographs taken by the new process.

ROENTGEN RAY DIFFUSION AND OPALESCENCE*—A NOVEL PHENOMENON.

BY ELIHU THOMSON.

So far as the writer is aware, the phenomena presently to be described have not hitherto been alluded to by writers or experimenters on Roentgen rays. They are the phenomena of diffusion of Roentgen rays by certain classes of substances in such a way that such substances must be regarded as opalescent or to act like opal glass with respect to ordinary light, or like milky liquids exhibiting diffusion of light from the interior and exterior of the mass.

Some substances are found to behave with Roentgen rays like compacted snow or translucent ice in diffusing light.

Let a large metal screen, such as a brass or iron plate, of one-sixteenth to one-eighth inch in thickness, be suspended in a vertical place about a foot or more from a Crookes tube kept in action and emitting Roentgen rays toward the plate. On the side of the plate opposite to that next the Crookes tube there will, of course, be a shadow space free from Roentgen rays. While this statement is true in the abstract, it may easily happen that an exploration with a fluorescent screen tube or fluoroscope back of the metal plate will sh w that the rays are not absent, but appear to come around the edge of the plate. This phenomenon has been alluded to by Mr. Edison, and used in support of his supposition that the rays are high-pitch sound.

But on close examination it will be found that the rays back of the metal shield are, mainly, at least, due to diffusion from surrounding objects—the walls or floor of the room, or objects receiving the rays and scattering them.

Further examination will disclose the fact that bodies differ greatly in their diffusive power, and that substances, such as paraffine, wood, paper, pine, rubber, cloth of cotton, or wool, the hand of the experimenter, etc., which are tolerably transparent to the rays, are also energetic in diffusing them. That the diffusion is not merely from the surface, and not simply diffuse reflection, is shown by the fact that the rays come also from the back of the object and from portions not exposed directly to the rays. This indicates a true opalescence, like that possessed by opal glass in ordinary light. The inference may readily be drawn from this that the shadows of opaque objects embedded in tissue at considerable depths can never be as sharp or black, so to speak, as when the objects are merely surrounded by air. Liquids appear to possess the property as well as solids. It must be borne in mind, also, that the diffusion appears to take place in all directions, within and without the mass of the substance. If the fluorescent screen tube used have thick metal sides, the large metal plate can be dispensed with. In this case it suffices that the screen tube be turned at right angles to the path of the rays or to direct it away from the Crookes tube in a line at an angle with the course of the rays. Pieces of various substances may now be placed opposite the end of the screen tube, but in a position to be partially or wholly exposed to the Roentgen rays. The pieces will become virtual sources of rays, and the diffused rays reaching the fluorescent screen will cause it to emit light.

By placing two exactly similar fluorescent screens at opposite ends of a dark tube, and employing a Bunsen photometer screen movable between them, a comparison of diffusing power of pieces of different materials might easily be made by subjecting the materials placed at the ends of the tube, respectively, to equal radiation from the Crookes tube. In fact, the relative effectiveness of two Crookes tubes as producers of the rays could be tested by such a "fluorometer" by passing the same discharge through both while they were opposite the ends of the "fluorometer." The comparative values of different fluorescent screens could also be tested by slight modifications in the use of the instrument.

The practical bearing of this property of diffusibility of Roentgen rays is found in the consideration that, in making images or shadows of bone structures, or opaque objects when a considerable depth of fleshy layer exists between the objects and the sensitive plate, there must of necessity be a blurring or lessening of contrast, owing to diffusion of the rays into the space back of the opaque bodies. Indeed, by using the fluorescent screen tube, it is easy to note that the shadow of a piece of sheet lead is very black when near the screen, although there may be a block of wood, paraffine, or the like, between the lead and the Crookes tube. But the shadow obtained when the wood or paraffine is between the lead and the fluorescent screen is not black, but somewhat milky, thus showing diffusion.

The writer has not tried the experiment, but thinks that a cloud in the air, or mass of fine particles of condensed water from a steam jet, would diffuse the rays. The higher-pitch light waves are most readily diffused and absorbed by fog, and if Roentgen rays be considered as very high-pitch waves, similar to light waves, this diffusibility should not surprise us. The new rays seem to be detectors of molecular turbidity, so to speak.

Whether true gases have the power of diffusing the rays is not known, but the diffusive power, if it exists at all, is probably very small in such cases.

There was apparently a minimum of diffusive action given by an exhausted incandescent lamp bulb, and what action there was probably came from the glass and may have been reflective.

The metal plates tried gave apparently little diffusive effect, but appeared to reflect feebly at angles equal to the incidence angles. The fluorescence of reflection from surfaces has been worked upon by Mr. Tesla, and a number of figures given of the relative reflecting powers of metals, etc., tried.

The diffusive action herein noted is different altogether from reflection, and is obtained at all angles with the surfaces of the material upon which the rays fall.

* Opalescence in this article is used to mean milkiness or cloudiness, not a play of colors.

New Press for Notching Armature Disks.

The well known press and die manufacturers, the E. W. Bliss company, 17 Adams street, Brooklyn, N. Y., are calling attention to a press of entirely new design for notching armature core disks, for which they claim superiority in several important respects over other machines for the same purpose. The machine is well illustrated by the accompanying half-tone engravings.

The adjustment for different diameters is made by simply turning the hand-wheel shown. No alteration or readjustment of pawls or indexing parts to suit different diameters is required.

The adjustment for different numbers of notches is effected by means of change-gears instead of the usual pawl and index-plate device. One gear only need be substituted to obtain any desired alteration in the number of notches. This obviates the necessity of using a special indexing plate for each style of disk, and effects a considerable saving, as the change-gears are comparatively inexpensive. If one notch is punched at each stroke, the number of teeth in the gear corresponds to the number of notches in the disk. If two or three notches are punched simultaneously, the number of teeth in the gear is made one-half or one-third, respectively, of the number of notches.

Two standard sizes are being introduced, designated by the makers as No. 16 A and No. 39 A. No. 16 A weighs about 1,500 pounds, and will take disks of from three inches to 30 inches in diameter. It is designed to be run at a high rate of speed—from 60 to 200 strokes per minute, according to the work being done. The larger machine, No. 39 A, weighs about 2,800 pounds. It will take disks of from five inches to 48 inches in diameter, and may be run at about 100 strokes per minute. For very large disks the No. 39 A machine is built with an extra large clamping and indexing frame, so constructed that it will take disks of from 10 inches to 60 inches.

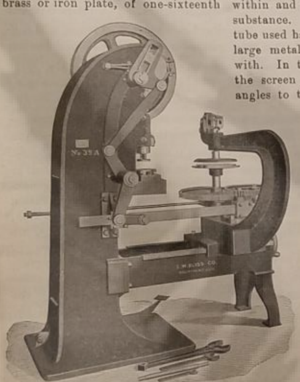


FIG. 1.—NOTCHING PRESS WITH CLAMPING ARM, SHOWING RACK AND PINION MECHANISM.

FIG. 2.—NOTCHING PRESS WITHOUT CLAMPING ARM, SHOWING AUTOMATIC STOP.

A Department of Commerce and Manufactures.

A bill which provides for the establishment of a Department of Commerce and Manufactures was introduced in the United States Senate on March 9, by Senator Frye, and was referred to the Committee on Commerce, in whose hands it now rests. This measure is one of great importance to the manufacturing and commercial interests of this country, and there is need for vigorous and immediate support of the bill by those whose interests it directly affects. To secure any action by the committee, or to obtain even a hearing upon the bill, it must be demonstrated to the members of the committee that the business men of the country are in favor of such legislation.

The ELECTRICAL REVIEW believes this movement is worthy of careful consideration, and suggests that its readers send to the National Association of Manufacturers, 1748 North Fourth street, Philadelphia, for free circulars of information on this subject, which is of undoubted importance to the electrical field.

ELECTRICAL REVIEW

Published at 13 Park Row,
P. O. Box 2339. NEW YORK.

EDITOR: CHARLES W. PRICE.
ASSOCIATE EDITOR: STEPHEN L. COLES.

REGISTERED CABLE ADDRESS: "ELECTVIEW," NEW YORK.

1546 "CORTLANDT," TELEPHONE CALL.

SUBSCRIPTION TO THE ELECTRICAL REVIEW.

One Year, United States and Canada, -	$3.00
One Year, Foreign Countries, - -	5.00
Single Copy, - - - - - - -	.10
Back Copies, each, - - - - - -	.25

SPECIAL NOTICE TO ADVERTISERS.

CHANGES for advertisements must be in this office by Friday noon for the following week's issue.

NEW ADVERTISEMENTS should be in the office not later than Saturday noon to insure publication the following week.

NEW YORK, APRIL 22, 1896.

CONTENTS.

INDEX OF ADVERTISERS.

COVER PAGES.

INSIDE PAGES.

There will be a lively gathering of the electrical fraternity in the metropolis next month. New York will extend a cordial welcome to these progressive visitors. May their stay be pleasant and profitable.

The contemplated combination of the General Electric Company's factories near Elizabeth, N. J., would be one of the wisest moves that that company could make. According to our news on the opposite page, it means that the company would be given a brand new manufacturing plant costing $1,000,000 and a cash bonus of $575,000. They would still hold their old plants at Schenectady, Lynn and Harrison as assets. It is to be hoped that every obstacle to the deal being completed may be removed. The company would make a considerable saving in its manufacturing cost besides securing other and equally important advantages.

Tesla's latest investigations of the many interesting scientific questions arising from the Roentgen ray discovery are published in this issue. No step in the various stages that he has so far presented to the readers of the ELECTRICAL REVIEW is more interesting or suggestive. The relation which he demonstrates to exist between the series obtained by arranging the metals according to their reflective power and Volta's contact series in air, proves that the rays emitted from the bulb are not an isolated phenomenon, but are emitted everywhere. Particularly suggestive is the observation that all conductors emit streams similar to those discovered by Roentgen, and that the sun and other sources of radiant energies must pour forth rays of the nature of the cathode. To those devoted chiefly to the practical applications of Roentgen's discovery, Tesla's latest observations with a fluorescent screen, showing that even the heart can be seen, will appear most promising, while his investigation of the important effect discovered by Prof. J. J. Thomson (who has contributed so much to the advancement along these lines) can not fail to be of the greatest interest to scientific men.

THE PATENT COMMITTEE COMPLETED.

Mr. E. B. Thomas, president of the Erie Railroad Company, has been selected as the fifth member of the committee to manage the patents of the General Electric-Westinghouse alliance. As Mr. Thomas is a very busy man, it was necessary to appoint an alternate to serve in case of his absence. The alternate has been selected in the person of Mr. Samuel Spencer, president of the Southern Railway Company.

Both Messrs. Thomas and Spencer are eminently able and fair-minded men, and were agreed upon unanimously by the General Electric and Westinghouse interests.

These appointments complete the committee. The four original members were named in the ELECTRICAL REVIEW for March 25, just a month ago. They are Messrs. C. A. Coffin and F. P. Fish, representing the General Electric Company, and George Westinghouse, Jr., and Paul D. Cravath, representing the Westinghouse Electric and Manufacturing Company. It is fair to presume that these gentlemen will administer the patent affairs of the two great corporations named in a just and impartial manner. It is understood that the committee has taken offices at 120 Broadway, New York city, at which address its business will be transacted.

TESLA'S LATEST ROENTGEN RAY INVESTIGATIONS.

To the Editor of Electrical Review:

Further investigations concerning the behavior of the various metals in regard to reflection of these radiations have given additional support to the opinion which I have before expressed; namely, that Volta's electric contact series in air is identical with that which is obtained when arranging the metals according to their powers of reflection, the most electro-positive metal being the best reflector. Confining myself to the metals easily experimented upon, this series is magnesium, lead, tin, iron, copper, silver, gold and platinum. The last-named metal should be found to be the poorest, and sodium one of the best, reflectors. This relation is rendered still more interesting and suggestive when we consider that this series is approximately the same which is obtained when arranging the metals according to their energies of combination with oxygen, as calculated from their chemical equivalents.

Should the above relation be confirmed by other physicists, we shall be justified to draw the following conclusions: *First*, the highly exhausted bulb emits material streams which, impinging on a metallic surface, are reflected; *second*, these streams are formed of matter in some primary or elementary condition; *third*, these material streams are probably the same agent which is the cause of the electro-motive tension between metals in close proximity or actual contact, and they may possibly, to some extent, determine the energy of combination of the metals with oxygen; *fourth*, every metal or conductor is more or less a source of such streams; *fifth*, these streams or radiations must be produced by some radiations which exist in the medium; and *sixth*, streams resembling the cathodic must be emitted by the sun and probably also by other sources of radiant energy, such as an arc light or Bunsen burner.

The first of these conclusions, assuming the above-cited fact to be correct, is evident and uncontrovertible. No theory of vibration of any kind would account for this singular relation between the powers of reflection and electric properties of the metals. Streams of projected matter coming in actual contact with the reflecting metal surface afford the only plausible explanation.

The second conclusion is likewise obvious, since no difference whatever is observed by employing various qualities of glass for the bulb, electrodes of different metals and any kind of residual gases. Evidently, whatever the matter constituting the streams may be, it must undergo a change in the process of expulsion, or, generally speaking, projection—since the views in this regard still differ—in such a way as to lose entirely the characteristics which it possessed when forming the electrode, or wall of the bulb, or the gaseous contents of the latter.

The existence of the above relation between the reflecting and contact series forces us likewise to the third conclusion, because a mere coinci-

dence of that kind is, to say the least, extremely improbable. Besides, the fact may be cited that there is always a difference of potential set up between two metal plates at some distance and in the path of the rays issuing from an exhausted bulb.

Now, since there exists an electric pressure or difference of potential between two metals in close proximity or contact, we must, when considering all the foregoing, come to the fourth conclusion, namely, that the metals emit similar streams, and I therefore anticipate that, if a sensitive film be placed between two plates, say, of magnesium and copper, a true Roentgen shadow picture would be obtained after a very long exposure in the dark. Or, in general, such picture could be secured whenever the plate is placed near a metallic or conducting body, leaving for the present the insulators out of consideration. Sodium, one of the first of the electric contact series, but not yet experimented upon, should give out more of such streams than even magnesium.

Obviously, such streams could not be forever emitted, unless there is a continuous supply of radiation from the medium in some other form; or possibly the streams which the bodies themselves emit are merely reflected streams coming from other sources. But since all investigation has strengthened the opinion advanced by Roentgen that for the production of these radiations some impact is required, the former of the two possibilities is the more probable one, and we must assume that the radiations existing in the medium and giving rise to those here considered partake something of the nature of cathodic streams.

But if such streams exist all around us in the ambient medium, the question arises, whence do they come? The only answer is: From the sun. I infer, therefore, that the sun and other sources of radiant energy must, in a less degree, emit radiations or streams of matter similar to those thrown off by an electrode in a highly exhausted inclosure. This seems to be, at this moment, still a point of controversy. According to my present convictions a Roentgen shadow picture should, with very long exposures, be obtained from all sources of radiant energy, provided the radiations are permitted first to impinge upon a metal or other body.

The preceding considerations tend to show that the lumps of matter composing a cathodic stream in the bulb are broken up into incomparably smaller particles by impact against the wall of the latter, and, owing to this, are enabled to pass into the air. All evidence which I have so far obtained points rather to this than to the throwing off of particles of the wall itself under the violent impact of the cathodic stream. According to my convictions, then, the difference between Lenard and Roentgen rays, if there be any, lies solely in this, that the particles composing the latter are incomparably smaller and possess a higher velocity. To these two qualifications I chiefly attribute the non-deflectibility by a magnet which I believe will be disproved in the end. Both kinds of rays, however, affect the sensitive plate and fluorescent screen, only the rays discovered by Roentgen are much more effective. We know now that these rays are produced under certain exceptional conditions in a bulb, the vacuum being extremely high, and that the range of greatest activity is rather small.

I have endeavored to find whether the reflected rays possess certain distinctive features, and I have taken pictures of various objects with this purpose in view, but no marked difference was noted in any case. I therefore conclude that the matter composing the Roentgen rays does not suffer further degradation by impact against bodies. One of the most important tasks for the experimenter remains still to determine what becomes of the energy of these rays. In a number of experiments with rays reflected from and transmitted through a conducting or insulating plate, I found that only a small part of the rays could be accounted for. For instance, through a zinc plate, one-sixteenth of an inch thick, under an incident angle of 45 degrees, about two and one-half per cent were reflected and about three per cent transmitted through the plate, hence over 94 per cent of the total radiation remain to be accounted for. All the tests which I have been able to make have confirmed Roentgen's statement that these rays are incapable of raising the temperature of a body. To trace this lost energy and account for it in a plausible way will be equivalent to making a new discovery.

Since it is now demonstrated that all bodies reflect more or less, the diffusion through the air is easily accounted for. Observing the tendency to scatter through the air, I have been led to increase the efficiency of reflectors by providing not one, but separated successive layers for reflection, by making the reflector of thin sheets of metal, mica or other substances. The efficiency of mica as a reflector I attribute chiefly to the fact that it is composed of many superimposed layers which reflect individually. These many successive reflections are, in my opinion, also the cause of the scattering through the air.

In my communication to you of April 1, I have for the first time stated that these rays are composed of matter in a "primary" or elementary condition or state. I have chosen this mode of expression in order to avoid the use of the word "ether," which is usually understood in the sense of the Maxwellian interpretation, which would not be in accord with my present convictions in regard to the nature of the radiations.

An observation which might be of some interest is the following: A few years ago I described on one occasion a phenomenon observed in highly exhausted bulbs. It is a brush or stream issuing from a single electrode under certain conditions, which rotates very rapidly in consequence of the action of the earth's magnetism. Now I have recently observed this same phenomenon in several bulbs which were capable of impressing the sensitive film and fluorescent screen very strongly. As the brush is rapidly twirling around I have conjectured that perhaps also the Lenard and Roentgen streams are rotating under the action of the earth's magnetism, and I am endeavoring to obtain an evidence of such motion by studying the action of a bulb in various positions with respect to the magnetic axis of the earth.

In so far as the vibrational character of the rays is concerned, I still hold that the vibration is merely that which is conditioned by the apparatus employed. With the ordinary induction coil we have almost exclusively to deal with a very low vibration impressed by the commutating device or brake. With the disruptive coil we usually have a very strong superimposed vibration in addition to the fundamental one, and it is easy to trace sometimes as much as the fourth octave of the fundamental vibration. But I can not reconcile myself with the idea of vibrations approximating or even exceeding those of light, and think that all these effects could be as well produced with a steady electrical pressure as from a battery, with the exclusion of all vibration which may occur, even in such instance, as has been pointed out by De La Rive. In my experiments I have tried to ascertain whether a greater difference between the shadows of the bones and flesh could be obtained by employing currents of extremely high frequency, but I have been unable to discover any such effect which would be dependent on the frequency of the currents, although the latter were varied between as wide limits as was possible. But it is a rule that the more intense the action the sharper the shadows obtained, provided that the distance is not too small. It is furthermore of the greatest importance for the clearness of the shadows that the rays should be passed through some tubular reflector, which renders them sensibly parallel.

In order then to bring out as much detail as possible on a sensitive plate, we have to proceed in precisely the same way as if we had to deal with flying bullets hitting against a wall composed of parts of different density with the problem before us of producing as large as possible a difference in the trajectories of the bullets which pass through the various parts of the wall. Manifestly, this difference will be the greater the greater the velocity of the bullets; hence, in order to bring out detail, very strong radiations are required. Proceeding on this theory I have employed exceptionally thick films and developed very slowly, and in this way clearer pictures have been obtained. The importance of slow development has been first pointed out by Professor Wright, of Yale. Of course, if Professor Henry's suggestion of the use of a fluorescent body in contact with the sensitive film is made use of, the process is reduced to an ordinary quick photographic procedure, and the above consideration does not apply.

It being desirable to produce as powerful a radiation as possible, I have continued to devote my attention to this problem and have been quite successful. First of all, there existed limitations in the vacuum tube which did not permit the applying of as high a potential as I desired; namely, when a certain high degree of exhaustion was reached a spark would form behind the electrode, which would prevent straining the tube much higher. This inconvenience I have overcome entirely by making the wire leading to the electrode very long and passing it through a narrow channel, so that the heat from the electrode could not cause the formation of such sparks. Another limitation was imposed by streamers which would break out at the end of the tube when the potential was excessive. This latter inconvenience I have overcome either by the use of a cold blast of air along the tube, as I have mentioned before, or else by immersion of the tube in oil. The oil, as it is now well known, is a means of rendering impossible the formation of streamers by the exclusion of all air. The use of the oil in connection with the production of these radiations has been early advocated in this country by Professor Trowbridge. Originally I employed a wooden box made thoroughly tight with wax and filled with oil or other liquid, in which the tube was immersed. Observing certain specific actions, I modified and improved the apparatus, and in my later investigations I have employed an arrangement as shown in the annexed cut. A bulb *b*, of the kind described before, with a leading-in wire and neck much longer than here shown, was inserted into a large and

(*Concluded on page 211.*)

GENERAL ELECTRIC FACTORIES TO BE MOVED.

THE SCHENECTADY, LYNN AND HARRISON PLANTS TO BE CLOSED —THE FINEST ELECTRICAL MANUFACTURING PLANT IN THE WORLD TO BE ERECTED FOR THE COMPANY NEAR ELIZABETH, N. J. —A DEAL OF LARGE PROPORTIONS.

The ELECTRICAL REVIEW is credibly informed from several sources that the General Electric Company will close its large factories at Schenectady, N. Y.; Lynn, Mass., and Harrison, N. J., and will remove its entire manufacturing business to a new and modern plant to be erected for the company near Elizabeth, N. J.

The deal is one of great magnitude and has been hanging fire for over a year and a half. Nearly all the obstacles to its successful accomplishment have been disposed of, and it is expected that the final arrangements may be concluded this week.

The idea had its origin with a syndicate of Elmira, N. Y., and western capitalists, who have made several successes with improvement and industrial enterprises involving heavy land transactions. These gentlemen have formed the New Orange Industrial Association with handsome headquarters at 253 Broadway, New York city. Mr. C. W. Manahan is general manager of the company. Mr. Matthew Arnot, a very wealthy banker of Elmira, is heavily interested in the company, and is understood to be ready to supply any amount of money to carry out the proposed project. He is credited with being worth $15,000,000.

The New Orange Industrial Association has acquired a tract of land lying between Elizabeth and South Orange, N. J., aggregating five square miles in area. Five prominent railroads cross this tract of land. The scheme includes the building of a standard gauge electric belt line railroad connecting the five steam roads.

In order to make this tract of land valuable, it was necessary for the New Orange Industrial Association to attract manufacturers, and to that end the company is said to have made a most liberal offer to the General Electric Company. This offer is stated to include the following: The land company will build, to the value of $1,000,000, a manufacturing plant after the General Electric Company's own designs, the plant to be turned over in fee simple to the General Electric Company on its completion. The land company is to give the electric company a cash bonus of $400,000 and a further allowance of $175,000 for moving expenses. The old factories belonging to the General Electric Company remain their property, and in time may be sold or leased for a considerable sum.

The combination of the company's manufacturing interests in one place means that 10,000 or more hands will find employment in their factories, and a good-sized town will be required to accommodate the workmen and their families. It is judged that the General Electric Company, by this move, can reduce its manufacturing expenses at least 10 per cent and gain besides the advantages of shipping freight over five of the principal railroads.

THE NATIONAL ELECTRICAL EXPOSITION.

SOME OF THE PROPOSED EXHIBITS.

Great interest is being manifested by manufacturers and others in all parts of the country in the National Electrical Exposition, which is scheduled to open on May 4, in the Industrial Building, Lexington avenue and Forty-third street, New York city. Following will be found further particulars of some of the proposed exhibits:

The Mica Insulator Company, New York city, will exhibit their mica and micanite insulating specialties.

The Crocker-Wheeler Electric Company, New York city, will make a comprehensive exhibit in their special field of work.

Spon & Chamberlain, the well known publishers, of New York city, will display electrical and scientific books and publications. Both members of the firm will attend the Exposition.

The new type of armature disk notching press, manufactured by the E. W. Bliss company, Brooklyn, N. Y., will be exhibited in connection with the Crocker-Wheeler dynamo.

The Goubert Manufacturing Company, New York city, will display their steam specialties in a space they have taken, and will show others as a working exhibit in connection with other apparatus.

The Watertown Steam Engine Company, Watertown, N. Y., will exhibit a 10x12-inch, high-speed engine direct connected to an Eddy dynamo. Messrs. Robert E. Cahill and L. Copleston will be in charge of the exhibit.

The Columbia Rubber Works Company, New York, will show a line of hard rubber specialties, such as hard rubber sheet, rod and tubing, telephone receivers and push buttons. They will also exhibit a new fireproof compound.

The Fuel Economizer Company, Matteawan, N. Y., will exhibit sample castings of their economizer, photographs, blue-prints and various plans of boiler houses showing the various applications of their economizers in plants now working.

The Kennedy Valve Manufacturing Company, New York city, will display a line of extra heavy gate valves, especially designed to meet the requirements of modern power plants. They will also show a line of their standard gate and globe valves.

The Bradford Belting Company, Cincinnati, will exhibit their dynamo belting and Monarch insulating paint, of which they are the sole manufacturers. Messrs. E. F. Bradford, O. M. Hubbard and E. P. Morris will be present during the Exposition.

The Harrisburg Foundry and Machine Works, Harrisburg, Pa., will exhibit a 12x12-inch Ideal engine direct connected to a 40-kilowatt Eddy generator. W. R. Fleming & Company, of New York, will represent the Harrisburg people at the Exposition.

Chas. A. Schieren & Company, New York city, will exhibit their specialties in the electrical line, consisting of large three-ply and double main driving belts, and smaller sizes for use on street railway generators and electric light dynamos and all high-speed work.

The Riker Electric Motor Company, Brooklyn, N. Y., will exhibit several of their new fan motors, standard Riker machines and a direct-connected plant, consisting of a Riker dynamo and a Case engine. The latter is similar to those the company installs for yacht-lighting.

The Nowotny Electric Company, Cincinnati, will show their ironclad motors and dynamos and a number of entirely new electric light specialties of their own manufacture. President L. R. Keck, General Manager John S. Nowotny, and Mr. Wm. M. Venable will be present.

The Phœnix Iron Works Company, Meadville, Pa., will exhibit a Dick & Church tandem compound, non-condensing, automatic cut-off engine of 125 horse-power, direct connected to a 75-kilowatt Walker generator. Mr. C. A. White, of the company's New York office, will have general charge of the exhibit.

The Straight Line Engine Company, Syracuse, N. Y., will show a 13x15-inch, 125-horse-power engine direct connected to a 75-kilowatt General Electric dynamo and a 10x14-inch, 80-horse-power engine direct connected to a Crocker-Wheeler dynamo. The latter engine, it is understood, will be driven by compressed air.

The Ashcroft Manufacturing Company, New York city, will have a prominent exhibit of consolidated safety valves, Metropolitan injectors, Mocrop recorders, and Edson pressure recording gauge. The manufacturing privilege for the latter, this company have recently secured. This exhibit will probably be one of the most interesting in the line of steam specialties.

The Electrozone Company, New York city, intend to exhibit a working model manufacturing electrozone, a working model showing the Woolf process of bleaching wood pulp by electricity, and a working model showing the Woolf process of manufacturing caustic soda by electrolysis. The potency of the electrical disinfectant will be shown by killing infusoria and the lower forms of animal germ life.

Stanley & Patterson, of New York, will display a line of general electric light and electric bell supplies. As eastern agents they will represent the New York & Ohio company, manufacturers of Packard lamps; Brunt & Thompson, manufacturers of porcelain goods; Indiana Rubber & Insulated Wire Company, manufacturers of Paranite wire, and the E. G. Bernard company, manufacturers of dynamos and motors. Messrs. Stanley, Patterson, Mead and Mays will be in attendance.

The E. T. Burrowes Company, Portland, Me., will exhibit models showing several styles of their automatic curtains for electric railway cars. They will also show a new waterproof curtain material called Oakette. Another part of their exhibit will be a cable device for holding curtains on an open car in place and a pinch handle device for an inside shade. While this exhibit will be small, the company will endeavor to make it interesting, as the curtain equipment of a car is by no means its least important feature.

The Standard Underground Cable Company, Pittsburgh, will exhibit a few reels of cable showing their standard fiber insulation and a specialty will be made of samples representing some of their most important recent contracts. There will also be a show rack for wires and cables and especially for small samples of lead-covered cable for distribution. Manager G. L. Wiley, of New York, and an assistant will attend the exhibition regularly, and Vice-president Marsh, of Pittsburgh, and Manager J. R. Wiley, of Chicago, will be present several days. The Standard company will distribute a novel electrical souvenir.

Hugo Reisinger, New York city, will make an extensive carbon exhibit, consisting of "Electra" high-grade Nuernberg carbons for arc lighting, for direct-current arc lamps on incandescent circuits, and for alternating current arc lamps; all descriptions of the finest grade of microphone carbons used in the manufacture of telephones; all descriptions of the very finest grades of battery carbons, and carbons used for search-lighting, for the manufacture of aluminum and for smelting all kinds of ores. Messrs. J. F. Outwater and Fred Nolker will represent Mr. Reisinger at the Exposition.

The exhibit of the Card Electric Motor and Dynamo Company, Cincinnati, will consist, in part, of the following apparatus: One 25-kilowatt generator directly connected to a Payne high-speed, automatic engine; a motor operating a Hoe press, the armature of the motor being directly connected to the shaft of the press in the place of the pulleys; a motor directly connected to a 37-inch Niles boring mill; a motor directly connected to a Niles six-foot radial drill and a three horse-power motor belted to a horizontal boring mill. They will also supplement their exhibit with some other special features which have as yet not been definitely decided upon.

In view of the importance of the occasion, the exhibit of the United States Patent Office at the National Electrical Exposition will be made one of unusual size and interest. As now arranged by the department, under the instructions of Mr. S. T. Fisher, the acting commissioner, it will include no fewer than 361 separate models of electrical devices, apparatus, machinery and appliances, many of them embodying the fundamental and elementary ideas upon which the modern electrical arts have been founded. These models will occupy over 300 linear feet, and will be carefully grouped and classified, so that students of whatever character can follow the general lines of growth or evolution.

The Partrick & Carter Company, Philadelphia, will exhibit a general line of house goods, consisting of hotel and house annunciators, burglar alarms, hotel fire-alarm systems and return calls, and also a full assortment of bells, pushes and numerous other household electrical appliances. They will have in operation a complete line of their own goods, and it is their intention, if possible, to have on hand, during the entire time of the exhibition, thoroughly competent attendants. They will call in from the road two or three of their most important salesmen, among them Mr. Thos. L. Townsend, who is known to the general trade from Maine to California, to be on hand to visit the firm's many friends who visit the Exposition. It is also the intention of the members of the firm to be at the Exposition as much as they can conveniently.

The General Electric Company will occupy 400 feet of space fitted up as a headquarters and general reception room. They will show, as a still exhibit, a number of their latest long burning arc lamps, a selection of inclined coil instruments and a few meters. They expect to have a representative collection of bromide prints illustrating the company's latest types of apparatus and photographs of representative installations. The Convention Committee of the company, consisting of S. D. Greene, chairman; Chas. T. Hughes, vice-chairman; Fred M. Kimball, secretary; A. D. Page, lamp works; T. Beran, of the New York Supply Department, and F. N. Boyer, of the Chicago Supply Department, will probably be present during the entire convention. Messrs. H. J. Buddy, representing the Philadelphia office; A. F. Giles, representing the Atlanta office; W. J. Ferris, representing the Chicago office, and Messrs. Chas. B. Davis, A. R. Bush, C. S. Haley and A. W. Ives, representing the Boston office, together with representatives from the railway, power, and mining departments and the New York office, will attend.

Keuffel & Esser company, New

York city, will show a handsome collection of drawing instruments and supplies and surveying instruments, such as are used in electric railway construction.

The C. W. Hunt company, New York city, will show Hunt's noiseless and frictionless conveyor adapted to the service of boilers in power stations. Mr. Harry P. Barr will be in charge of the exhibit.

Huebel & Manger, Brooklyn, N. Y., will make a handsome display of their electrical and brass goods. Mr. W. W. McChesney, Jr., will be in charge, and the members of the firm will be present to welcome their friends.

The Birdsall Electric Manufacturing Company, of New York city, will show a novel line of combination electrical specialties, which will undoubtedly attract attention. A few of them were recently described in the ELECTRICAL REVIEW.

The Stanley Electric Manufacturing Company, Pittsfield, Mass., will exhibit a two-phase S. K. C. generator, a two-phase alternating current motor, transformers and switchboard apparatus. Mr. T. E. Theberath, the company's New York representative, will have charge of the exhibit.

The Peru Electric Manufacturing Company, Peru, Ind., will make a complete display of all the different pieces of porcelain which they manufacture, together with an exhibition of their Laclede and Hercules batteries. Messrs. Bouslog, Schutt and Stevens will be in charge of the exhibit.

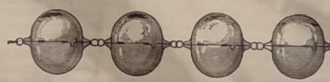
The Crane company, New York city, will show samples of their extra heavy I. B. gate valves for 200 pounds working pressure, extra heavy I. B. globe and angle valves for 200 pounds working pressure, standard and indicator valves, iron body blow-off valves, extra heavy flanged fittings for 200 pounds working pressure, and samples of many of their smaller specialties, such as brass valves, Pope safety valves, water relief valves and the like.

The Interior Conduit and Insulation Company, New York city, have secured a large space and will show in operation a printing press run by a direct-connected Lundell motor, exhaust fan outfits, 60 inches, 36 inches and 12 inches; direct-connected generating set, Lundell power motors, Lundell generators, Lundell desk-fan motors and ceiling-fan motors, Lundell dental outfits, Lundell emery wheel grinder, Lundell buffing machine and Lundell organ-blowing outfit. The latter outfit will be attached to a Mason & Hamlin organ, which will be played each evening. The company will also exhibit their complete system of plain, brass-armored and iron-armored insulating conduits as well as their complete underground conduit system. An illuminated sign 30 feet in length will be shown. The following-named gentlemen will be in attendance and explain the various novelties: Messrs. D. C. Durland, Geo. H. Kimber and E. B. Kittle.

In connection with the opening ceremonies of the National Electrical Exposition, when it is proposed to start the machinery by a circuit that has first looped in the whole continent, the Postal Telegraph Cable Company, through its vice-president, Mr. W. H. Baker, has very courteously offered its fine service between New York and San Francisco for the purpose. The Postal company has been equipping its lines with heavy copper circuits and believes that it can illustrate rapidity of working by the instantaneity of its transmission on May 4, when the mere pressure of the golden key will flash the signal to the golden gate and back to the Exposition building in the twinkling of an eye. Arrangements are now being made with the Postal officials for the execution of this interesting plan, with the co-operation of the long string of offices scattered over the 6,000 miles of wire.

J. C. Vetter & Company, New York city, will make an exhibit to demonstrate the application of the constant incandescent current in electro-therapeutics, by means of various instruments designed for the purpose. This apparatus consists of the following: Vetter current tap, by means of which the current from any lamp socket can be carried to a droplight or fan motor without interfering with the lamp; current adapter, by means of which the lamp in the socket can be placed in series, and the current thus reduced and limited by the capacity of the lamp; carbon current controller; volt controller; standard milliammeter; cautery rheostat and various combinations of the above apparatus in the way of table bases, switchboards and cabinets. A feature of this exhibit will be a cabinet lately designed, which, in connection with the constant incandescent current, furnishes for electro therapeutical purposes the galvanic current, faradic current, sinusoidal current, cautery current, motor current and current for small diagnostic lamps. All these currents can be modified and manipulated to the finest degree. Mr. A. F. Vetter will attend the Exposition.

The Payne Engine Company, of 41 Dey street, New York city, and Elmira, N. Y., will have one of their new type direct-connected engines of 50-horse-power capacity connected to a 25-kilowatt card generator. This machine will undoubtedly be of unusual interest, from the fact that it will have an improved inertia governor of an exceedingly simple form of construction, and one for which is claimed very superior results. The governor consists of but two pieces and one bearing, thus reducing friction to the minimum and the chances of disarrangement. It is stated by manufacturers that this governor will move through the entire range, viz., from 0 to 5/8 cut-off in less than one-fifth of a second, and it overcomes what is commonly known as "dancing" in the centrifugal governor. The Payne people will have another feature which will attract a good deal of attention. It is an automatic return oil circulation system, by means of which the oil is delivered in a stream to the main bearings by gravity, and drained to a central point at the bottom of the base. By means of a small oil pump working on the rocker arm of the valve rod, it is pumped to the receptacle on top of the frame, where it is filtered and reused. Carefully designed oil guards prevent any oil being thrown from the engine; and at the same time it is not the inclosed type. The Payne company will be represented at the Exposition by S. H. Payne, N. B. Payne and F. N. Jewett, of the New York office.



SOCKETLESS DECORATIVE INCANDESCENT LAMPS.

Realizing the impracticability of adequately exhibiting the working of its complicated and extensive plant in any reasonable space, the Metropolitan Telephone and Telegraph Company will make an exhibit illustrative of its New York city service as viewed from the user's standpoint. The manner in which this will be carried out involves, nevertheless, a more elaborate installation than might appear from the exhibit proper, as the company will place telephone stations at a number of exhibitors' spaces, as well as at points where service is desired by the Exposition company. These stations will be connected to a switchboard in the company's space, thus forming a small exchange within the exhibition itself. This service will be furnished without charge to the exhibitors and to the Exposition company by the Metropolitan Telephone Company, which will furnish the entire installation and maintain the service at its own expense. Besides the switchboard, the company will install in its own space four silence booths of different types, each equipped with telephone instruments of the various styles used by New York city subscribers. These will all be working stations connected with the Thirty-eighth street exchange and will be available to visitors to the exhibition in the same way as an ordinary public pay station. This remarkably useful form of exhibit will no doubt be highly appreciated by exhibitors who can not fail to realize the convenience of being placed in easy communication with each other and with their home offices. The exhibit proper will afford the public ample illustration of the excellent service furnished by the Metropolitan company and of the high grade of equipment provided for public and subscribers' stations. Those visitors who display particular interest in the operation of a city telephone system will be invited to visit one of the company's large exchanges, where they can examine in detail the nature and operation of the plant, which are practically impossible of reproduction in an ordinary exhibition.

PERSONAL.

Mr. C. M. Morse, of the Buffalo Engineering Company, Buffalo, N. Y., visited New York city last week.

Mr. Albert L. Johnson, of Cleveland, has been elected president of the Nassau Electric Railway Company, of Brooklyn, N. Y.

Among the out-of-town electrical men who visited New York city last week were Messrs. Estep, of Pittsburgh; C. J. Mayer, of Philadelphia, and Louis Myer, of Chicago.

Mr. P. H. W. Smith has been appointed assistant general manager of the Standard Underground Cable Company. Mr. Smith's training in electrical matters was received at Lehigh University, of which he is a graduate. He has been actively connected with the Standard Underground Cable Company for a number of years in the construction and sales departments, and the advancement is well merited and will be appreciated by his many friends. Mr. F. S. Viele has been made manager of the conduit and the general construction departments. Mr. Viele is a graduate of Massachusetts Institute of Technology in Electrical Engineering, and his ability in matters pertaining to insulated wires and cables makes him a valuable man for the company.

A Socketless Decorative Lamp.

The Empire Lamp Works, 154 and 156 West Twenty-seventh street, New York city, have just placed upon the market a series decorative incandescent lamp with which no socket is required. The accompanying illustration shows the lamps half size. They are made for three candle-power to run four in series on 50 to 60 volts, and eight in series on 110 to 120 volts. The lamps are especially suitable for decorative and display effects, and when hung in chains and festoons present a very beautiful appearance.

"I tell you what," said a fat, red-faced man as he stood in Park Row one evening last week; "I was just going to take that horse-car there, but I didn't, not on your tin-type, when I saw the sign in the window."

"What was it?" asked a friend.

"What was it?" repeated the fat man, scornfully. "What was it? It was 'This car is heated.' These horse car managers must be gibbering idiots."

THE HISTORY OF ELECTRIC HEATING APPLIED TO METALLURGY.

READ BEFORE THE WASHINGTON SECTION OF THE AMERICAN CHEMICAL SOCIETY BY FREDERIC P. DEWEY.

(Concluded from page 193.)

In 1887–88 a series of patents was granted to M. P. L. T. Heroult, in which alumina was melted by the passage of the current and then electrolyzed with molten copper, or iron, as the cathode with which the separated aluminum alloyed.

The furnace (Fig. 8) was a suitable containing vessel of carbon to which the negative wire was attached. The positive electrode was of carbon. In running the furnace, copper or iron was first put in and melted by the current, then alumina was added, which was also melted and then electrolyzed by the current. More alumina and copper, or iron, were added from time to time, and the resulting alloy was tapped out periodically.

This was a very promising high heat alloying process, but it, as well as the Cowles process, was superseded in the aluminum field by the Hall process of producing the pure metal, of which it is only necessary to say here that in this process the charge is both melted and electrolyzed by the current, but the fact is to be emphasized that only a comparatively low temperature is required.

From 1892 to March 15, 1895, there has been much published regarding the work of M. Henri Moissan, who has done so much fine work in the field of high temperatures, and has accomplished such wonderful results.

He employed various styles of furnaces and different amounts of current. His early furnace (Fig. 9) consisted of a simple block of quicklime suitably bound and provided with electrodes and a cover. In this, some very interesting results were obtained. Another furnace (Fig. 10) was especially designed for determining the temperature by the specific heat method. A piece of carbon was put on the end of one electrode, the current passed and the carbon pushed off from the electrode; at the same time a slide was withdrawn from the bottom of the furnace and the hot carbon allowed to fall in the calorimeter below. A number of temperature determinations were made in connection with M. Violle. Another furnace (Fig. 11) was provided with tubes for the introduction of gases. In this, pure and colorless carbide of silicon was formed from carbon and silicon vapors. This furnace also had various layers, beginning with lime on the outside, and followed by carbon and then magnesia on the inside, or vice versa. Another furnace (Fig. 12) had transparent ends of glass, or mica, so that the operations could be watched. It also had magnets to direct and control the arc.

In this, Moissan designed to investigate and study the simple heating effect of the current separated as much as possible from any electrolytic effect. He speaks of and treats the arc as one would speak of an ordinary flame.

Moissan began with a very moderate current of 35 to 40 amperes at 55 volts, and passed through various stages up to 1,200–1,600 amperes at 110 volts.

A few of the results obtained by Moissan may be mentioned. Magnesia was the only irreducible oxide found; it was melted and volatilized. Lime, strontia and magnesia began to volatilize before melting. Lime was easily melted and the metal calcium reduced, but it immediately combined with the carbon vapor, forming calcium carbide (CaC_2). Alumina and platinum were volatilized. Artificial diamonds were produced. Various temperatures from 2,000 degrees to about 3,800 degrees centigrade were measured. Carbon begins to volatilize at about 3,500 degrees centigrade. Various quantities of the rarer metals were reduced 200 to 300 grammes of uranium; 100 grammes of vanadium; 10 kilos of chromium, as well as manganese.

As in practical flame work, the amount of fuel burned determines the temperature of the furnace, so in this case the amount of current passed determines the temperature and the furnace must be designed to stand the current to be employed. While Moissan's small furnace will stand the temperature developed by small currents, yet with 1,200 amperes at 110 volts the lime and magnesia melt down, volatilize rapidly, and in a few moments the furnace is spoiled at a temperature of about 3,500 degrees centigrade.

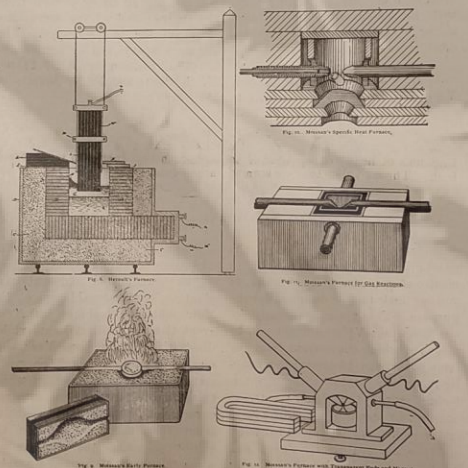
For materials of construction it was found that lime was the best non-conductor for heat, but its fusibility and the ease of forming the carbide prevent its use for the inside of the furnace at very high temperatures. Compared with lime, carbon is a good conductor of heat. Magnesia is also a better heat conductor than lime. It does not form carbide of magnesium, and therefore can be heated very hot in direct contact with carbon, while lime can not. It, however, is volatile, and can be melted at very high temperature. Practically, therefore, the outside of the furnace is quicklime, while the interior is variously lined with carbon or magnesia, or both, and when carbon is in direct contact with the lime it must not get too hot at the point of contact.

In 1893 a United States patent, No. 492,767, was issued to E. G. Acheson, in which a mixture of silica, carbon and salt was heated by the passage of the current, and silicon carbide produced, which has found considerable application as an abrasive.

In the present early stage and activity of the calcium carbide and barium carbide questions, it might not be wise to go into the details of the work and the claims of the various workers (Borscher, Maquenne, Moissan, Travers, Willson—I arrange these names simply alphabetically), but I mention these various carbide processes to show the present condition of our subject, and to draw especial attention to a notable fact.

In reviewing our subject we find that in the early days the current was suggested, tried and used for various metallurgical operations, in which both the heating and decomposing actions of the current were utilized. Then in the principal, practical part of the field, that of the production of sodium and aluminum, the generation of intense temperatures became paramount. This activity culminated in the high heat processes of Cowles and Heroult, and they were very soon superseded by the low temperature process of Hall for the production of aluminum, which carried with it the greater part of the demand for the production of sodium.

At the present day, therefore, there is no practical production of metals by high electric heats, with the possible exception of the production of chromium. On the other hand, high electric heats are being employed to go a step beyond the reduction of the metals, and to form new compounds, as in the carbide processes mentioned. In these the metals are first reduced and are then immediately recombined with carbon, and thus in the field of high heat our subject becomes the application of high electric heat to chemistry.



ELECTRIC FURNACES MENTIONED IN "THE HISTORY OF ELECTRIC HEATING APPLIED TO METALLURGY."

Medico-Legal Society.

At the monthly dinner of the Medico-Legal Society, held at the Hotel Marlborough, New York city, on April 15, Dr. J. Mount Bleyer read a paper on "The Roentgen Rays in Medico-Legal Surgery."

TELEPHONE NEWS AND COMMENT.

There are said to be 150 opposition telephone companies in Ohio, Indiana, Illinois, Michigan and Wisconsin.

The directors of the Central Union Telephone Company have reduced the quarterly dividend from one and one-quarter per cent to one per cent.

The annual meeting of the New England Telephone and Telegraph Company will be held in New York May 4. Books closed April 2 and will open May 5.

The Central New York Telephone and Telegraph Company has issued its official list of subscribers No. 11. The list covers Syracuse, Utica and surrounding towns and is conveniently arranged.

A committee of the directors of the Erie Telegraph and Telephone Company have just returned from a thorough inspection of the telephone property in Minnesota, Arkansas and Texas, which they report in excellent condition.

The Elkhart, Ind., Telephone Company prints the following on its directory of subscribers: "Our rates are five cents per day for residences and seven cents for business houses. We have no war rates. Our office and exchange is over 229 South Main street. Come and see us."

The Erie Telegraph and Telephone Company has at present 28,000 miles of exchange lines, 19,000 subscribers and is increasing at the rate of 2,400 per annum. Already $200,000 has been invested in real estate, and it is the intention of the company to erect its own buildings in cities where there are 700 subscribers. These buildings cost about $15,000 each.

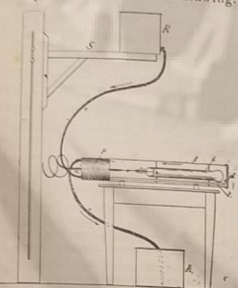
The Southern Massachusetts Telephone Company has commenced the work of putting its wires underground in Brockton, Mass., and expects to finish the job about July 1. The city wires will go underground with the telephone company's wires, but the electric light company will be compelled to find another way of providing for their wires, as it has been notified by the telephone company that it is intended to remove the poles in July.

A circular has been issued by the American Bell Telephone Company respecting the issue of 21,500 new shares of stock. Each stockholder of record March 31, 1896, is entitled to take and pay for shares of the new stock in the proportion of one share for every 10 shares thus held. This right to subscribe will expire at 10 o'clock Saturday, May 16, 1896. Payment for full shares equal to one-half of the shares so subscribed for at the rate of $200 for each share must be made to the treasurer Wednesday, July 1, 1896, and for the remainder on Thursday, October 1, 1896.

TESLA'S LATEST ROENTGEN RAY INVESTIGATIONS.

(Concluded from page 207.)

thick glass tube t. The tube was closed in front by a diaphragm d of pergament, and by a rubber plug P in the back. The plug was provided with two holes, into the lower one of which a glass tube t_1, reaching to very nearly the end of the bulb, was inserted. Oil of some kind was made to flow through rubber tubes r r from a large reservoir R, placed on an adjustable support S, to the lower reservoir R_1, the path of the oil being clearly observable from the drawing.



By adjusting the difference of the level between the two reservoirs it was easy to maintain a permanent condition of working. The outer glass tube t served in part as a reflector, while at the same time it permitted the observation of the bulb b during the action. The plug P, in which the conductor c was tightly sealed, was so arranged that it could be shifted in and out of the tube t, so as to vary the thickness of the oil traversed by the rays.

I have obtained some results with this apparatus which clearly show the advantage of such disposition. For instance, at a distance of 45 feet from the end of the bulb my assistants and myself could observe clearly the fingers of the hand through a screen of tungstate of calcium, the rays traversing about two and one-half inches of oil and the diaphragm d. It is practicable with such apparatus to make photographs of small objects at a distance of 40 feet, with only a few minutes exposure, by the help of Professor Henry's method. But, even without the use of a fluorescent powder, short exposures are practicable, so that I think the use of the above method is not essential for quick procedure. I rather believe that in the practical development of this principle, if it shall be necessary, Professor Salvioni's suggestion of a fluorescent emulsion, combined with a film, will have to be adopted. This is bound to give better results than an independent fluorescent screen, and will very much simplify the process. I may say, however, that, since my last communication, considerable improvement has been made in the screens. The manufacturers of Edison's tungstate of calcium are now furnishing screens which give fairly clean pictures. The powder is fine and it is more uniformly distributed. I consider, also, that the employment of a softer and thicker paper than before is of advantage. It is just to remark that the tungstate of calcium has also proved to be an excellent fluorescent in the bulb. I tested its qualities for such use immediately and find it so far unexcelled. Whether it will be so for a long time remains to be seen. News reaches us that several fluorescent bodies, better than the cyanides, have been discovered abroad.

Another improvement with a view of increasing the sharpness of the shadows has been proposed to me by Mr. E. R. Hewitt. He assumed that the absence of sharpness of the outlines in the shadows on the screen was due to the spread of the fluorescence from crystal to crystal. He proposed to avoid this by using a thin aluminum plate with many parallel grooves. Acting on this suggestion, I made some experiments with wire gauze, and, furthermore, with screens made of a mixture of a fluorescent with a non-fluorescent powder. I found that the general brightness of the screen was diminished, but that with a strong radiation the shadows appeared sharper. This idea might be found capable of useful application.

By the use of the above apparatus I have been enabled to examine much better than before the body by means of the fluorescent screen. Presently the vertebral column can be seen quite clearly, even in the lower part of the body. I have also clearly noted the outlines of the hip bones. Looking in the region of the heart I have been able to locate it unmistakably. The background appeared much brighter, and this difference in the intensity of the shadow and surrounding has surprised me. The ribs I could now see on a number of occasions quite distinctly, as well as the shoulder bones. Of course, there is no difficulty whatever in observing the bones of all limbs. I noted certain peculiar effects which I attribute to the oil. For instance, the rays passed through plates of metal over one-eighth of an inch thick, and in one instance I could see quite clearly the bones of my hand through sheets of copper, iron and brass of a thickness of nearly one-quarter of an inch. Through glass the rays seemed to pass with such freedom that, looking through the screen in a direction at right angles to the axis of the tube, the action was most intense, although the rays had to pass through a great thickness of glass and oil. A glass slab nearly one-half of an inch thick, held in front of the screen, hardly dimmed the fluorescence. When holding the screen in front of the tube at a distance of about three feet, the head of an assistant, thrust between the screen and the tube, cast but a feeble shadow. It appeared some times as if the bones and the flesh were equally transparent to the radiations passing through the oil. When very close to the bulb, the screen was illuminated through the body of an assistant so strongly that, when a hand was moved in front, I could clearly note the motion of the hand through the body. In one instance I could even distinguish the bones of the arm.

Having observed the extraordinary transparence of the bones in some instances, I at first surmised that the rays might be vibrations of high pitch, and that the oil had in some way absorbed a part of them. This view, however, became untenable when I found that at a certain distance from the bulb I obtained a sharp shadow of the bones. This latter observation led me to apply usefully the screen in taking impressions on the plate. Namely, in such case it is of advantage to first determine by means of the screen the proper distance at which the object is to be placed before taking the impression. It will be found that often the image is much clearer at a greater distance. In order to avoid any error when observing with the screen, I have surrounded the box with thick metal plates, so as to prevent the fluorescence, in consequence of the radiations, reaching the screen from the sides. I believe that such an arrangement is absolutely necessary if one wishes to make correct observations.

During my study of the behavior of oils and other liquid insulators, which I am still continuing, it has occurred to me to investigate the important effect discovered by Prof. J. J. Thomson. He announced some time ago that all bodies traversed by Roentgen radiations become conductors of electricity. I applied a sensitive resonance test to the investigation of this phenomenon in a manner pointed out in my earlier writings on high frequency currents. A secondary, preferably not in very close inductive relation to the primary circuit, was connected to the latter and to the ground, and the vibration through the primary was so adjusted that true resonance took place. As the secondary had a considerable number of turns, very small bodies attached to the free terminal produced considerable variations of potential on the latter. Placing a tube in a box of wood filled with oil and attaching it to the terminal, I adjusted the vibration through the primary so that resonance took place without the bulb radiating Roentgen rays to an appreciable extent. I then changed the conditions so that the bulb became very active in the production of the rays. The oil should have now, according to Prof. J. J. Thomson's statement, become a conductor and a very marked change in the vibration should have occurred. This was found not to be the case, so that we must see in the phenomenon discovered by J. J. Thomson only a further evidence that we have to deal here with streams of matter which, traversing the bodies, carry away electrical charges. But the bodies do not become conductors in the common acceptance of the term. The method I have followed is so delicate that a mistake is almost an impossibility.

NIKOLA TESLA.

New York, April 20.

Law Battery Company Burned Out.

The new plant of the Law Battery Company, at Cranford, N. J., was burned out on April 18. The heavy machinery was not damaged and the other losses are fully covered by insurance. The company is prepared to fill orders as usual.

New Telephone and Telegraph Companies.

CHEROKEE, IOWA—The Cherokee Telephone Company has been incorporated by James F. Weart, R. L. Robie, A. B. Ross, W. H. Lysaght and W. A. Sanford. Capital stock, $25,000.

CHELSEA, MICH. — The Chelsea Telephone Company has been incorporated by Lynn L. Gorton, Henry Gorton, A. W. Wilkinson and others. Capital stock, $10,000.

WARREN, VT.—A telephone line is to be put in between this place and Roxbury, and will eventually be connected with the Northfield exchange.

INDIANAPOLIS, IND.—The Crown Point Telephone Company has been incorporated. Capital stock, $10,000. George W. Fisher is interested.

MADISON, WIS. — It is reported here that the Postal Telegraph Company intends extending its line from Freeport to this place, and that an office will be opened here by June 1. Guy E. Paine, manager of the Postal company in Chicago, is in the city looking for a suitable office.

NATIONAL ELECTRIC LIGHT ASSOCIATION.

RAILROAD ARRANGEMENTS.

To the Editor of Electrical Review:

Arrangements have been made whereby delegates on the line of the Chicago & Alton road can use that road to Chicago and connect with the electrical special at that point for a fare and one-third, on the certificate plan. This will enable the St. Louis delegates to leave that city at 11.30 P. M., reaching Chicago at 8.30 A. M. the following day, which will enable them to remain in the latter city until the time the electrical special leaves, namely, 5 P. M. Saturday, May 2.

Very truly yours,

C. O. BAKER, JR.,
Master of Transportation.

New York, April 17.

HOTEL ARRANGEMENTS.

To the Editor of Electrical Review:

I am pleased to inform you that the Murray Hill Hotel, Forty-first street and Park avenue, has been selected as the hotel headquarters for delegates to our nineteenth convention, May 5, 6 and 7.

It is stipulated, however, by the hotel management that none of the guests make use of any part of the hotel for exhibition purposes or display any signs or placards in the halls or corridors.

The Exposition to be held under the auspices of this association will open May 4 in the Industrial Building, two blocks from the hotel headquarters.

Respectfully,

GEO. F. PORTER,
Secretary.

New York, April 17.

Carbide of Calcium—Acetylene Gas.

The *Progressive Age* of April 15 presents the report of a commission which that enterprising journal sent to Spray, N. C., to investigate acetylene. The gentlemen were Messrs. Houston and Kennelly, of Philadelphia, and Dr. Leonard P. Kinnicutt, chemist. After a very exhaustive test the decision of the commissioners is summed up in the following table and paragraph:

Materials per day and per ton of gross carbide	$14.39
Labor per day and per ton of gross carbide	11.00
Water power, 1,229 5-365	3.37
Petty stores, waste, etc., $150 per annum	.41
Taxes at $100 per annum	.274
Interest on investment at five per cent, $11,955	1.638
Depreciation and repairs, five per cent on electric plant and turbine	1.218
Six per cent on countershafting, building, rolls and crusher	.446
Twenty per cent on furnaces	.021
	$32.767

Our estimate, therefore, of the cost of producing calcium carbide at Spray—by working the furnaces 365 days a year and 24 hours a day, yielding on the average one ton of 2,000 pounds gross carbide a day—is $32.767 per ton. Of this amount $14.39 is for material. The freight charges on lime and coke are heavy at Spray and add materially to the cost.

Walter K. Freeman Convicted.

Walter K. Freeman, an electrical engineer, formerly of New York city, was convicted on Friday last in the Court of General Sessions in this city of criminal assault in the second degree. The extreme penalty for this crime is 10 years imprisonment.

THE [illegible] ELECTRICAL WEEKLY IN THE UNITED STATES.

ILLUSTRATED ELECTRICAL REVIEW

A Journal of Scientific and Electrical Progress.

Vol. XXVIII.—No. 21. NEW YORK, WEDNESDAY, MAY 20, 1896. TEN CENTS A COPY. THREE DOLLARS A YEAR.

THE "A. B." ARC LAMP

THIS IS THE

"Evoluted" Arc Lamp

the lamp station men have been looking for all these years.

They have given the old style lamp a 20-years' tussle and are getting tired.

Too many trimmers and patrolmen spoil the balance sheet.

The sliding contact must go.

The double-carbon lamp must go.

All the springs must go.

All the shadows must go.

The unsightly chimneys must go.

The carbon rod must go.

Wedging carbons must go.

This Lamp Has Come, Consequently All Arc Lamp Difficulties MUST GO.

BE SURE to read the paper at the Convention on "The Evolution of the Arc Lamp."

BE SURE to see our exhibit at the Exposition.

THE ADAMS-BAGNALL ELECTRIC CO.,

.... CLEVELAND. ....

NEW YORK OFFICE, 222 HAVEMEYER BUILDING.

ILLUSTRATED
ELECTRICAL REVIEW
A Journal of Scientific and Electrical Progress.

VOL. 28. No. 21. WEEKLY. | NEW YORK, WEDNESDAY, MAY 20, 1896. | $3 PER ANNUM. Single Copies, 10 Cents.

Entered at Post Office, New York, as Mail Matter of the Second Class.

VIEWS, NEWS AND INTERVIEWS.

Many of the readers of the ELECTRICAL REVIEW will remember the projector which Mr. L. H. Rogers installed on top of the Pulitzer Building, in New York city, to throw portraits and advertising signs on the clouds. In speaking of this apparatus the other day, Mr. Rogers stated that the apparatus was all right, but that it couldn't work without clouds. He waited 45 days in New York for a cloud to show up, and then when it came it was so thin the sign went right through it. Mr. Rogers received, a short time ago, an offer from the Russian state officials to install his projector apparatus in Moscow during the ceremonies attendant upon the coronation of the Czar. It was intended to throw various coats-of-arms and insignia upon the clouds by means of his projector. The money consideration was very tempting, but the time required to ship the apparatus to Moscow was too short to permit of its being used. "And then, besides," said Mr. Rogers, "how did I know they have any clouds in Moscow?"

The death of Henry C. Bunner, editor of *Puck*, which occurred at Nutley, N. J., on May 11, removes from the literary world one of the few truly genuine humorists. In his work Mr. Bunner exhibited a rare combination of pathos and humor, which has and will continue to delight and amuse thousands of readers.

Mr. H. L. Shippey, secretary of the John A. Roeblings' Sons Company, the well known wire manufacturers, and builders of the Brooklyn Bridge, recently returned from an extensive trip to South Africa, where he was at the time of the Jameson raid. Dr. Jameson and his companions were in jail at Pretoria and Mr. Shippey did not meet them. He saw Cecil Rhodes and became well acquainted with Mr. Charles Leonard, the president of the Transvaal National Union. Mr. Shippey said:

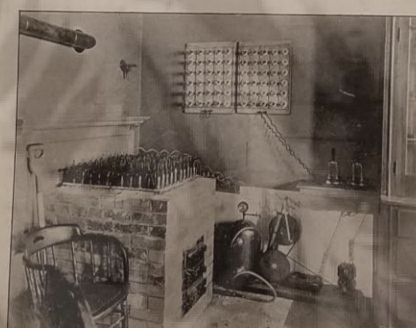
"I spent several weeks on the same ship with Mr. Leonard, and, as you know, one gets to know a man at pretty close quarters on board ship. I formed of Mr. Leonard the opinion that he was as sincere, honest, upright and straight as any man I ever knew. I formed the highest opinion of his integrity and probity."

For the Boers Mr. Shippey had little good to say.

"They are sneaky fellows, who would as soon stab you in the back as not," he declared. "I didn't like them at all. They make English-speaking people as uncomfortable as they can all the time. They are overbearing, arrogant and not to be trusted. Traveling from Cape Town to Johannesburg, I was thoroughly searched, and the Boer officials make no attempt to show one even ordinary courtesy. The feeling is very strong, not only against the English, but against English-speaking people, such as Americans or Australians. I had to get a passport, an elaborate document, to prove my identity before I could go through the Orange Free State."

The London *Electrical Review* recently printed the following: "We have long been impressed with the importance of the field for electrical enterprise that is gradually opening out in Australia and New Zealand. Edison has, according to the *Sydney Telegraph*, commenced operations in that immense district, and, doubtless, being convinced that matters should be stirred there as soon as possible, he has formed, or has arranged with others to form, the Australian Edison Electric Company, for the purpose of handling the whole of his inventions throughout Australia." When the above paragraph was shown to Mr. Edison he said it was news to him.

As already announced in the ELECTRICAL REVIEW an unfortunate accident happened last week to Prof. Elihu Thomson, of Lynn, fracturing the bone of his leg just above the ankle. Although not necessarily serious, it will delay the professor's work considerably. He has been an enthusiastic investigator of the Roentgen discovery, and after the fracture was set had an X-ray picture taken of it. The result was very satisfactory, showing the surgical adjustment of the bone to be most perfect and only a fine line showing the break. Another picture will be taken with an improved Boston tube immediately, and even clearer results are expected. He is at present at his residence, at Swampscott, Mass.



VIEW IN THE LABORATORY OF DR. W. W. JACQUES, SHOWING HIS APPARATUS FOR THE PRODUCTION OF ELECTRICITY DIRECT FROM COAL.

The Jacques Carbon Generator.

In the ELECTRICAL REVIEW of a few weeks ago was given a description of an electrical generator devised and patented by Dr. William W. Jacques, of Boston, in which electrodes of iron and carbon were employed with an electrolyte of melted caustic soda. The carbon is the soluble element; it is claimed for this cell that it is highly successful in operation and caps the climax of the electrician's dearest hopes for the past 15 years in giving the public a practical coal battery. In the REVIEW article above referred to the prior efforts of Jablochkoff and others in this art were adverted to, and the fact noted that nothing commercially serviceable and cheap had been produced. It is claimed that Dr. Jacques's generator is in no sense a *battery*, as the electrolyte of fused caustic soda does not attack the carbon except in the presence of air. It is not apparent how the apparatus can operate at all unless it is by galvanic action, though, of course, the presence of air may be required to maintain a constant action, since the very nature of electrolytic conduction is galvanic and decomposition must take place as a necessary prerequisite before current can pass from pole to pole. In an elaborate article in the *Boston Herald* of May 11, it is stated that 100 cells in series, comprising iron pots one and a half inch in diameter and 12 inches deep, each containing a cylinder of carbon, maintained thirty 16-candle lamps burning at full brilliancy, and used eight pounds of coal in 18¾ hours, giving a current of 90 volts and 16 amperes, and realizing 82 per cent of the theoretical efficiency of burning coal.

Professor Charles R. Cross is said to have indorsed these tests. These are altogether astonishing results, if, as stated, but a small percentage of the energy of the coal used is required to maintain the apparatus hot enough to keep the soda in fusion. An illustration of Dr. Jacques's apparatus in his Boston laboratory is presented on this page.

THE EVOLUTION OF THE ARC LAMP.

READ BEFORE THE NATIONAL ELECTRIC LIGHT ASSOCIATION, NEW YORK, MAY 7, 1896, BY L. H. ROGERS.

For the purpose for which it is intended to be used, the arc lamp, as we commonly know it, is mechanically and electrically the poorest designed and constructed piece of mechanism on earth.

The author of such a statement could only conscientiously proclaim it upon such an occasion as this, before a body of men who are thoroughly familiar with arc lamps, who can instantly spot the first sign of a lack of logic in the argument which must necessarily follow such a radical statement.

Washington was still alive when Volta, a Frenchman, discovered the energy displayed in the consumption of certain metals when immersed in acids. It was simply impossible for him to have realized at that time what the invention or discovery of the primary battery meant.

A few years after this, in 1802, Sir Humphry Davy connected up a large number of Volta's cells. He connected the positive of one cell with the negative of the next one, the positive of that with the negative of the next, and so on. After connecting about 2,000 cells together thus, in series, he attached a piece of charcoal to the positive of one end of the line and another piece of the same material to the negative of the last cell in the row. Then, first touching the pieces of charcoal together and afterwards drawing them slightly apart, the first arc lamp was produced. The pieces of charcoal were in a horizontal position, and as the heated atmosphere between the points caused the flame or mass of illuminated particles to bend upwards in the form of an arch, the name of "arch" light was given to this new form of illuminant.

This term has since been changed to "arc."

History gives us no information regarding the importance attached to Davy's new light, by his neighbors, his wife, or even his scientific associates. It is more than probable that all of them looked upon him as a cranky old professor, foolishly wasting his time and money.

Certain it is, that it was utterly out of the question for any one of that time to imagine that before the close of the century Davy's light would become the commercial light of the world.

In fancy, I lead Davy through the city of Philadelphia, with her streets illuminated by 6,351 arc lamps—the best lighted city on earth—and try to catch some conception of his thoughts as he realizes what his two pieces of charcoal have done for mankind.

It requires 1896 to appreciate 1802.

Some one has said that Faraday was the greatest discovery of Davy's. It must have been that Davy's teachings found good and fruitful soil when instructing his youthful pupil.

It was in 1832, three years after the death of Davy, that Michael Faraday discovered the principles of electro-magnetic induction.

This was a giant stride in the ultimate development of the arc lamp, for the reason that by the applications of those principles the modern dynamo was born. What Faraday did for the world can better be understood if we can imagine primary batteries of equal capacity and power, in lieu of all the dynamos now used for arc and incandescent lighting. The contemplation is sufficient to cause us to love Michael Faraday.

In place of the large number of troublesome and cumbersome cells, the electric potential or energy necessary to maintain an arc between the two pieces of charcoal was now generated mechanically, rather than chemically, with one piece of machinery, rather than a large number of acid-slopping jars.

No sooner had Faraday announced his discovery, than scores of inventors and experimenters began to construct and perfect dynamos. Some great mind like Faraday, or Roentgen, lets down the bars to the Elysian fields, and thousands rush in and stake out all the choice corner lots. These swift-footed inventors, however, are necessary to the evolution of an industry.

Beginning with 1832, one dynamo followed another in rapid succession. Each successive machine embraced some new device or new idea overlooked in its predecessor.

Improvements also began to be made in the device which transformed the electric energy into light. Davy's light, although blinding to the eye, became wearisome, simply as an experiment. It was found that the pieces of charcoal were gradually consumed as they were burned—the one attached to the positive end at the rate of about twice that at the negative end. This lead to the necessity of providing some means of feeding the pieces of charcoal towards one another as they wasted away. The pieces of charcoal themselves were improved. They were hardened and baked, and therefore called carbons.

Thus began the arc lamp on its long, rough journey towards perfection. The first efforts were very crude. The electric current passing through the lamp was utilized to cause a screw to revolve slowly. At the end of this screw was attached the positive carbon, which in this manner was fed towards the lower or negative carbon.

It is easily seen that the nearer the carbon points approached each other, the less became the resistance and the greater became the flow of the current. Likewise, the greater the distance between the carbon points, the greater the resistance and the less the flow of the current. This ebb and flow of the electric current provided magnetic power of varying strength, which was early seen could be utilized to operate the mechanism to feed the positive carbon. The disadvantage of this, however, soon manifested itself in the fact that as the current was augmented and diminished by the proximity and separation of the carbon points, the current in the line itself was proportionately affected. This made the operation of two or more lamps on the same set of wires impossible, for the reason that the carbons in the different lamps could not be depended upon to feed at the same instant, as well as the effect on the regulation of the dynamo.

The operation of more than one light from one machine was, therefore, attended with difficulty from the time of Faraday's discovery, in 1832, up to 1875. Some little success was obtained during this period by running a set of wires from the machine to each lamp desired to be operated, though no illuminating to any extent was done in this manner, except as a laboratory experiment.

About the year 1875 it occurred to a young electrician, Charles F. Brush, living in Cleveland, that if he could, construct a device for an arc lamp which would regulate the feeding of that lamp without affecting the main line, it would then be possible to operate any number of lamps on one circuit, as the current momentarily required to operate the feeding mechanism in any given lamp would leave all the others undisturbed. This was a bold idea, and required inventive genius of a high order to carry it out.

Up to this period a magnet had been employed in the lamp mechanism, which consisted of a coil of wire wound around a hollow spool, into which was inserted an iron core. When the current was switched on, the action of the coil was to draw the core into the spool. This movement provided means for raising and lowering the upper carbon. Mr. Brush used two spools for added strength. The normal path of the current was around these two spools (in parallel) to the carbon and down through the carbons and then to the negative terminal. He, however, constructed another possible path for the current. Attaching a wire of quite small cross-section to the main wire, he wound it on the same spools, but in an opposite direction to that of the coarser wire. This fine wire, after leaving the spools, passed directly to the negative terminal, making what was termed a "shunt" around the arc. The effect of this unique arrangement was the same as a controller on an engine. The more current passing through the fine wire the weaker the magnet became, and the all important point gained that each and every lamp was a law unto itself, establishing and regulating the arc, and feeding without influencing any other lamp on the circuit.

The device termed "differential winding," or "feed," was entitled successful, and to Charles F. Brush belongs the credit of first giving to the world commercial arc lighting. He accompanied this invention with one not much less in importance.

He invented a cut-out—a device for cutting out any given lamp, provided any trouble should happen to that lamp, so that it could not burn. This cut-out insured the absolute maintenance of the main circuit, no matter what might happen to any single lamp.

Visitors to the World's Fair in 1893 will not soon forget the impressive exhibit made by Krupp, of Germany, the gunmaker of the world. Here at one side was shown a piece of iron eight inches thick, and there by its side a gun invented for the special purpose of piercing that piece of iron with a projectile. At the next step was seen a thicker or tougher piece of metal with a more powerful gun to pierce it. And thus the race between gun and metal was maintained, until a weapon 35 feet long, mounted upon a carriage which was revolved, lowered and elevated by special machinery, was exhibited, of such power that it could throw a 2,200-pound ball two miles, and at that distance pierce the toughest wrought iron plate 36 inches thick.

In a somewhat similar manner a race has been in progress between the device for generating the electric current and the device for transforming said current into light—the dynamo and the lamp. Volta invents a battery and Davy matches it with his lamp—a light formed between two pieces of charcoal. After 30 years Faraday discovers an entirely new method of producing the electric current, and scores of inventors immediately proceed to improve the lamp to meet the new conditions. For 40 years after this time improvements in the dynamo and the lamp proceed by easy stages, hand in hand, until the invention of the differential winding, which has placed the lamp far in advance of the dynamo. Immediately this winding was perfected, then began the rapid improvement of the dynamo, to meet, if possible, the new and improved conditions brought about by its use. For the past 20 years and more this improvement of the dynamo has been in progress, until to-day machines highly efficient, close in regulation and producing current for 125 2,000-candle-power arc lamps are as common as the poorly constructed, inefficient 16-light dynamos were 20 years ago.

These large machines are wonders in their class. It is possible to throw all of the lamps in or out of the circuit at once, break the main line or, in fact, do anything to break down the machines electrically, and they continue to run, automatically taking care of their load, and without the least hitch of any kind. The efficiency of these machines is in some cases as high as 90 per cent. In short, perfection has been about reached in the arc dynamo.

On the other hand, the arc lamp as it stands to-day is a poor affair compared to what it might be. It is far behind the arc dynamo as regards electrical and mechanical perfection. What was considered good enough or even perfect 20 years ago will not answer to-day. New uses have arisen for the electric light, and its adoption as an illuminant has exceeded any prophecies ever made for it. The dynamo has again more than outreached the lamp, and the time for a new lamp has arrived.

THE ARC LAMP MUST MEET THE DEMAND.

Remember that the title of this paper is "The Evolution of the Arc Lamp," and that evolution denotes a continuous development. Since Brush perfected the fundamental principles of the commercial arc lamp, what has been done? In 1875 the arc lamp was a great ball of wonderment. From 1878 to 1880 a few were induced to really try them practically. During the next decade the mad lighting fever was in full sway, and 250,000 arc lamps had been hung up in the United States by 1890. The manufacturing companies were too busy shipping and collecting to think of anything but of something which would burn. The lighting companies were too busy making contracts with municipalities and supplying the demand for light to ever look to see what was inside the lamp.

But this is the age of close inspection. Municipalities are not paying $350 per year for a 2,000-candle-power arc lamp in 1896. They encourage other companies entering their city limits, and this brings keen and active competition. If competition is not encouraged, or if prices for lighting are not reduced, the "tax-payer"—that tireless individual who never dies—is heard from, and starts the agitation for a municipal plant on the theory of his new discovery that electricity costs nothing to "make."

It is not the purpose here to discuss this swing of the pendulum from too high prices—it has, indeed, swung too far already in the other direction—but it does behoove us to examine closely into the daily expenses and annoyances to which the electric lighting plant is subjected.

There is no business which has developed so rapidly and so radically as that of electric lighting. The frame building, 20 feet square, has been replaced by a handsome brick and iron roofed structure, 150 by 300 feet, and three stories high. The deliberate saw-mill engine, at 90 revolutions, has been replaced, first by the diminutive busy little high-speed engine at 350 revolutions, then by a larger type of the slow-speed engine, and later by a compound

condensing engine at a piston speed of 800 feet per minute. The transmitting devices have been changed from belt to rope, and rope to direct. The boilers have undergone a radical change, and the manufacturer must now guarantee the pounds of water evaporated, per pound of coal, by his make. Remarkable and needed improvements have been made in the dynamo, as we have mentioned. The efficiency has been raised from 50 to 85 or 90 per cent. A 125-light machine gives less trouble and care to run than an old 10-lighter.

In all this development; in this search for high efficiencies; in this attempt to get running expenses down to the minimum; the arc lamp has been overlooked. The most important single piece of mechanism in the entire system, it has been the last to receive serious attention.

There are 2,711 central lighting stations in the United States, with $320,000,000 invested. The sole and only object of this outlay is to get light. The engines, dynamos, belting, conduits, buildings, are all secondary to the arc lamp. It is the exponent of the entire problem. It is literally in the "eye of the public" day and night. Its lines of—I was about to say beauty, but whoever heard of a beautiful arc lamp? At any rate, it stands against the morning sky or the evening sunset, and, in truth, I hear the public say: "It must be the best the electricians can do, for I have watched for 15 years, but have seen no change; they are all alike in their hideousness."

And now let us look at the subject squarely. Let us hold the arc lamp up between the fluorescent screen and the Crookes tube, and in the light of X-ray, 1896 knowledge, examine the arc lamp hanging in our streets.

We find a device, 50 to 60 inches long, made of long tubes or chimneys, a sheet-iron drum, long side rods, and at the bottom a globe-holder. We can see Davy's two pieces of charcoal; one is 12 inches long and the other six. The rate of consumption has not changed. We realize that the useful length of this lamp is the vertical length of the carbons. Dividing 18 inches by 50 inches, we find that the useful length of this device is only 36 per cent of its total length. The statement may be made by some enthusiastic observer that there are two pairs of carbons—one pair alongside the other—but he must not forget that with our improved eyesight in 1896 we can look clear through the device and see not only the skeleton, but the marrow in the bones.

These carbons are fastened firmly in their respective holders, and the holders are rigid. The burning of the arc causes the carbons to point up quite decidedly. When the current is shut off momentarily, these points fall together and it very often happens slip by each other and wedge. When the current is again sent through the coil, its lifting power is not sufficient to pull the carbons apart, the lamp is rendered utterly useless, the policeman reports it out, and a deduction is made from the bill of the lighting company to the city. To prevent these deductions amounting to more than the original bill, a corps of patrolmen are engaged, whose business it is to watch the lamps all night long, to prevent them going out, as a nurse would watch a sick child.

We find the interior of the devices full of springs, some of them with ratchets and cog wheels, some with six magnets or coils,—all with three or more—springs without number and of every size, regulating devices, auxiliary levers, light and flimsy pieces of every shape and size, the device for gripping the rod—in most cases an annular ring gripping the carbon rod by tilting so that its knife-edge holds on the side of the rod, the current being conducted to the carbon rod by means of a sliding contact—delicate brushes against which the carbon rod rubs as it feeds the carbons downwards, cut-out spools which have little side shows of their own with independent armatures and additional coils of wire, carbon rods sticking away up into the dark recesses of the chimneys—rods which must be carefully housed and carefully cleaned with crocus cloth each day. We notice also that for three or four inches above the casing the rod can not be cleaned by the trimmer; it therefore becomes spotted; a bit of weather or a bit of dust changes the nature of the brass, and the current-carrying brush, when it reaches this spot, does not make a good connection; a little blister is formed, which in turn blisters the surface of the brush, and this in turn blisters the rod the entire length until crocus cloth is powerless to smooth it. The lamp then must come in, for in the meantime many other little things have happened, and nothing but a thorough overhauling will put the lamp in good condition again.

It would require a volume to recount the details of the troubles that are occurring every hour in every lighting plant on the face of the globe. You, who are within reach of my voice, know too well that your arc lamps give you more trouble than all the rest of your apparatus combined. These troubles have come upon you so gradually, however, that you have become accustomed to them. It seems that some station men actually delight in keeping a force of men repairing old lamps, and a horse and wagon busy hauling them in and taking them out again.

Alexander Dow, electrician for the city of Detroit, connects four 100-light dynamos to one engine, for the reason, as he states, that the ratio of troubles is four to one. I wonder how many dynamos would be connected to each arc lamp, or arc lamps to dynamos, provided the number were dependent on the ratio of troubles?

And now we have reached the year 1896; we have given the arc lamp a 20 years' tussle, and our troubles are increasing rather than diminishing. The lamp cuts the same kind of a figure against the sky as it did in the year 1875. Many details have been added in the interior construction, more magnets, and more springs, and more cut-outs, and more chimneys, and less glycerine—but I do not think the statement can be denied that not one single idea of great merit has been added to the arc lamp between 1875 and 1895.

If this be true, is it not time to consider the question seriously? Are we to give up the question and acknowledge that hanging on our streets is the world's best effort for the distribution of light through the medium of the arc lamp?

Is evolution to be the password to progression in all the arts; in fact, in everything except the arc lamp?

To return to the opening sentence of this paper, "For the purpose for which it is intended to be used, the arc lamp, as we commonly know it, is, mechanically and electrically, the poorest designed and constructed piece of mechanism on earth."

I am not here to decry the lamp of any manufacturer. It is, however, pertinent to say that any lamp which will allow the carbons to slip by or wedge, under any circumstances, is mechanically imperfect. It is an inherent defect in the lamp, and the damages or outages should be charged to the manufacturer of the lamp. What mechanism has determined that the proper way to hold two slim, sharply pointed pencils in a coaxial position is to fasten them rigidly at their extremities, 18 inches distant, and then depend on their sharpened points nosing each other correctly? A very much better way would be to leave the carbon-holder loose and free, centering by guiding the carbons near the arc. This would make trimming a very easy matter, and admit of cross-eyed men being employed. On second thought, however, we run immediately into difficulties, for, as we can not change the rate of consumption of the positive carbon, the arc would soon reach one of the guides and burn it away. This would then require a lamp with a stationary arc, and that would require carbons of different diameters—upper and lower—and that would mean a great deal of thinking for the inventor and manufacturer, and so the lamps go out; and the station manager, believing that the arc lamp has been fully evoluted, keeps sending his orders to the manufacturer, and the manufacturer will never improve as long as he can fill his orders with old-style apparatus.

A sliding contact is a poor arrangement in an arc lamp. It has been tried as thoroughly as any idea ever could be tried. It is the direct cause of the roughness of the rod. The resistance of the contact is too easily increased by the presence of a little dust. The sliding contact in the arc lamp must go.

The carbon rod itself is a troublesome institution. With an annular ring for a clutch, it must be kept in a uniform, polished condition, or it will give trouble. It is responsible for the unsightly hideous chimneys, which ought not to be in sight and yet which can not be draped. As we are building a new lamp let us dispense with the carbon rod altogether. We can then cut off the chimneys and shorten up the lamp. Then we can, without much trouble, parallel the carbons with the operating mechanism and increase the percentage of useful length to total length to at least 80 per cent. With a short lamp we can make a casing of light cast-iron in such shape as to avoid the necessity of a hood. We can also increase the carbon length, and if we do this we can choose our own size of carbons; that size for upper which will produce the largest crater, and that size for lower which will best let the light out.

Thus we come back and meet, but overcome, our first difficulty. We construct a focusing lamp, and this leads us to the thought that there is only one correct position for the arc inside the globe, anyway, and that the arc should be stationary. If we hang the upper carbon on a chain suspended over a shieve, and attach the lower carbon to the lower end of the chain, we can, with proper adjustment, accomplish many things. As the upper carbon feeds downwards, as it is being consumed, the chain can be of equal weight—inch for inch therewith. Therefore, when an inch of upper carbon has been consumed, and its weight taken from the cross-head, an inch of chain has been added, and the armature remains in the same plane between the pole-pieces of the magnet as before. This is an absolute necessity where the same difference of potential is required throughout the entire range of burning.

Thus we are not restricted by the weight of the carbon, and can use whatever size is most suitable. It having been demonstrated that with eight, nine or ten amperes $2\frac{5}{8}$-inch carbon will produce a larger crater and give more initial light than any other size, it remains only to determine the length necessary for burning 14 to 16 hours. This length has been found to be 14 inches. With an upper carbon of $\frac{5}{8}$x14 inches, we find that $\frac{1}{2}$x12 negative plain will burn an equal length of time, leaving an equal stub and keep the arc practically in the same position during the entire run. This small lower carbon will let out the intense light in the crater of the upper, the increase of light at 45 degrees being something which would astonish most experimenters.

We must not forget that 320 millions of money is invested in the central stations alone in the United States simply to get light, and more light with the same expenditure of energy should be a welcome statement by those interested.

By quotations from all leading carbon manufacturing companies of the country, the point is discovered that a pair of $\frac{5}{8}$x14 and $\frac{1}{2}$x12 carbons is the cheapest possible combination for 14 to 16 hours' burning. Any one can test this point. It is simply the price of one $\frac{5}{8}$x14 plain and one $\frac{1}{2}$x12 plain carbon against three $\frac{1}{2}$x12 plain or $\frac{7}{16}$x12 copper-coated carbons. I have quotations in my pocket which will make a difference of $2.50 per lamp per year, assuming the full number of burning hours nightly, in favor of the $\frac{5}{8}$x14 and $\frac{1}{2}$x12 carbons.

Again, a $\frac{5}{8}$ upper and $\frac{1}{2}$ lower, loose at the joints and guided near the arc, will absolutely prevent wedging

(Concluded on page 266.)

THE EXHIBIT OF PARTRICK & CARTER COMPANY, OF PHILADELPHIA, AT THE NATIONAL ELECTRICAL EXPOSITION, NEW YORK CITY.

ELECTRICAL REVIEW

Times Building, 41 Park Row,
P. O. Box 2339. NEW YORK.

EDITOR: CHARLES W. PRICE.
ASSOCIATE EDITOR: STEPHEN L. COLES.

REGISTERED CABLE ADDRESS: "ELECTVIEW," NEW YORK.
1846 "CORTLANDT," TELEPHONE CALL.

SUBSCRIPTION TO THE ELECTRICAL REVIEW.

One Year, United States and Canada,	$3.00
One Year, Foreign Countries,	5.00
Single Copy,	.10
Back Copies, each,	.25

SPECIAL NOTICE TO ADVERTISERS.

CHANGES for advertisements must be in this office by Friday noon for the following week's issue.

NEW ADVERTISEMENTS should be in the office not later than Saturday noon to insure publication the following week.

NEW YORK, MAY 20, 1896.

CONTENTS.

INDEX OF ADVERTISERS.

COVER PAGES.

Have you ever noticed what a *penchant* electrical men possess for shaking hands with people they meet? One man at the Electrical Exposition the other night was observed to shake hands with 12 men in as many minutes. Promiscuous hand-shaking is a waste of energy which electrical men, as engineers, should be the first to recognize.

TESLA'S ACHIEVEMENTS IN VACUUM TUBE LIGHTING.

The ELECTRICAL REVIEW has from the outset closely followed the promising work of Nikola Tesla. We had the privilege of announcing in 1886, for the first time, Tesla's investigations in a system of electric lighting. Early in 1888 we were the first to announce his epochal discovery of the multiphase system of power transmission, and since that time it has been our pleasant duty to keep our readers well informed on the various subjects of his important researches, of which we only mention his latest contributions to the great discoveries of Roentgen, which were exclusively published in our columns. It is, therefore, no small satisfaction for us to now first record another significant advance of this indefatigable worker. Ever since Tesla showed in his memorable lecture before the American Institute of Electrical Engineers, five years ago, the fascinating experiments with vacuum tubes, he has untiringly labored on, simplifying and improving his methods, not for a moment diverted by other tasks—nor even discouraged by so great a calamity as the recent destruction of his laboratory—from the problem of producing an efficient and practical system of electrical illumination.

No more impressive result of Tesla's earnest efforts could be shown than that which is outlined in our present issue. The portrait of the great inventor, which, especially in view of the extraordinary way in which it was obtained will not fail to interest the scientific world, is a striking illustration of what he has done. Surely, since he has produced a vacuum tube which is capable of supplying any volume of light desired, even more than a powerful arc light, we can not hesitate to express our positive conviction that the introduction of a more perfect illuminant is near at hand.

The observing editor of the *Morning Advertiser* has noticed the dimness of the Liberty torch on Bedloe's Island and is inclined to blame electricity for it and suggests a visit of electrical experts to see what is the matter. It doesn't require any expert to suggest a remedy. What is needed is a little more liberality on the part of the penurious United States Government in the matter of coal. A little more coal in the grate, a little more steam in the boilers, a few more revolutions per minute of the dynamo's armature, and the light will shine bright again. It is really a shame that, after accepting this plant as a gift, the government should pay so little attention to its proper care.

THE SIZE OF ELECTRICAL BOOKS.

In our issue for April 15 we expressed an opinion that it would be greatly to the advantage of the busy electrical man if publishers would make electrical books of a size to slip easily in one's pocket. Our esteemed contemporary, the London *Electrical Review*, takes a similar view of the case in its issue for May 1, as follows:

The electrical man has hardly time to sneeze nowadays, so busy is he running his plant or carrying out extensions. Therefore, ten chances to one, he will not be able to read cumbersome books, however important the subject, and be his desire ever so ardent. The tendency in electrical matters is towards conciseness, and it must be so in publications in particular to meet the requirements of such a man as the electrical engineer. As well as conciseness, this all-important being needs compactness; and this is a point which publishers of technical works should take to heart. The smaller the size of an electrical book, the more use it will be, and, consequently, the larger its sale. What is wanted is not a book the size of a family Bible, but one in size of page and cover similar to a pocketbook, so that when these odd moments occur the engineer can take it from his pocket and digest a little at a time, and think it over as he goes about or when his attention may not be specially upon his work. Publishers should make a note of this point. It is worth considering.

THE FINANCIAL SIDE.

Electrical matters were very quiet in financial circles this week, about the only interest being the annual meeting of General Electric, held at Schenectady on Tuesday, the 12th instant. That stock was steady around 34, and the bonds sold at 90¾. Edison Electric Illuminating of New York bonds sold from 103 to 104.

I attended the General Electric meeting with the expectation of hearing from the preferred shareholders in the matter of a correction of the capital impairment and the payment of accrued dividends. Not a word was said upon the subject, and only routine business was transacted.

I learned from an unquestioned source that the next move that will be taken, with a view of correcting the capital impairment, will, in all probability, be a suit by the preferred shareholders to force the payment of something like 21 per cent dividends, now in arrears. This would result in a decision by the courts as to the company's legal right to pay these dividends.

On the Boston Exchange, Bell Telephone yielded fractionally to 205¼. Transactions were light. Erie Telephone at 60 and New England Telephone at 90 were unchanged. General Electric preferred was strong, advancing 2 points to 74 on improved prospects of back dividends. In Philadelphia the Electric Storage Battery stocks continued their upward creep. The common is now selling at 35⅛ and the preferred at 36¼. The Pennsylvania Heat, Light and Power Company lost 1 point to 14½. BAIN.

New York, May 16.

TESLA'S IMPORTANT ADVANCES.

HIS REMARKABLE ACHIEVEMENTS IN VACUUM TUBE LIGHTING.

A representative of the ELECTRICAL REVIEW visited the laboratory of Mr. Tesla last week and found him engaged in putting the final touches to certain improvements in vacuum tube illumination. He was enthusiastic as to the results arrived at to such a degree that he expressed his positive confidence as to having made very important advances.

While reluctant to speak at present extensively on the subject of his most recent investigations, he authorized the statement to the effect that he has been most successful in several lines of work he has been following up for a long time, only temporarily interrupted by the lamented destruction of his laboratory by fire about a year ago.

When asked about his often-mentioned oscillator he said that a commercial machine is now being completed with which he expects to show the superiority of this mode of generating electricity.

He further stated with evident elation that in the study of the Roentgen phenomenon he has made great progress, so much so that he is now able to perceive through an Edison improved Roentgen-screen, recently purchased from Aylsworth & Jackson, of this city, the heart of an assistant so clearly as to note its expansions and contractions. In some instances he could locate evident defects in the lungs of a number of persons.

As to his continuous efforts to improve his system of lighting by vacuum tubes, with which he has been identified during a number of years, Tesla said that he has been more successful than he had ever dared to hope. His methods of conversion from ordinary to high-frequency currents are rendered simple in the extreme, the devices are thoroughly reliable and require no attention. Last, but most important of all, he has succeeded in increasing the candle-power of the tubes to practically any intensity desired.

A remarkable and most telling result of the advances he has made in the last direction is a portrait, which he has reluctantly allowed us to use, and which was obtained by *two seconds'* exposure to the light of a *single vacuum tube* of small dimensions. Tesla stated further that photographs obtained by the light of such powerful tubes show an amount of detail which no picture taken by the sun or flash light is capable of disclosing. This feature is only faintly shown in the reproduction on this page. The photograph was made by Tonnelé & Company, artists' photographers, who aided Mr. Tesla in his attempts to photograph by the light of phosphorescent tubes about two years ago.

When asked, Mr. Tesla said, in explanation of the picture, speaking with deep feeling, that the volume he was reading was one of the "Scientific Papers," of Maxwell, given to him as a token of friendship by Professor Dewar; the chair a gift of his warmest friend, Mr. E. D. Adams; and as to the queer coil to

TESLA IN HIS LABORATORY—PORTRAIT OBTAINED BY AN EXPOSURE OF TWO SECONDS TO THE LIGHT OF A SINGLE VACUUM TUBE WITHOUT ELECTRODES, HAVING A VOLUME OF ABOUT 90 CUBIC INCHES, GIVING APPROXIMATELY A LIGHT OF 250 CANDLE-POWER—PHOTOGRAPHED BY TONNELÉ & CO. COPYRIGHTED BY THE "ELECTRICAL REVIEW."

his left, Mr. Tesla hesitatingly remarked that it was the object "dearest of all in his laboratory," having been a most valuable instrument in his many-sided investigations.

Mr. Tesla added, good humoredly, that, had it not been for the extraordinary manner in which the photograph was taken, he would not have given this explanation even to such an important personage as the representative of the ELECTRICAL REVIEW.

The *Western Electrician* felicitates itself on getting its issue of May 9 to New York on May 2. This western enterprise is a question merely of dating ahead—and because of the news and up-to-date information that does not, but should, appear appeals solely to the amiable minds to be found in the editorial office of our blue-countenanced contemporary.

General Electric Company's Annual Meeting.

The annual meeting of the General Electric Company was held at Schenectady, N. Y., on May 12. The representation of stock was 201,000 shares. George Foster Peabody was elected a director in place of Thomas K. Cummings, Jr. The balance of the old board of directors was re-elected. Only routine business was transacted and the question of capital impairment was not brought up.

President Charles A. Coffin, of the General Electric Company, was seen by one of the editors of the *Wall Street Journal* recently, and stated that negotiations had been under way for the removal of the company's works from Schenectady, but that these had been dropped for the present. Mr. Coffin further stated that the patent agreement with the Westinghouse company will go into effect June 1. It will not change the style or character of apparatus manufactured at the works in any substantial respect. The patent agreement has been under consideration long enough to warrant the belief that it will result in a considerable increase in business for the two companies and a shade better prices. The directors have not, for various reasons, formulated any definite plan for correcting the impairment of capital. The preferred shareholders have recently taken up the question for formal consideration and it is not impossible that some plan of dealing with the matter may be outlined at an early date.

Mr. W. J. Camp, of Montreal, electrician of the Canadian Pacific Telegraph, was a New York visitor last week, conferring with Electrician F. W. Jones, of the Postal Telegraph.

THE DESIRABILITY OF A STANDARD SOCKET.

TOPIC DISCUSSED BEFORE THE NATIONAL ELECTRIC LIGHT ASSOCIATION, NEW YORK, MAY 7, 1896, BY ALFRED SWAN.

The topic which I introduce deals with the vexed question of lamp sockets. Its object is to promote an interchange of opinion on the part of those present who are interested in the subject, and by its discussion before this convention give to the question that status which its importance demands.

This question of the standardization of the lamp socket was recently raised by the *Electrical Engineer* and various letters appeared in the journal on that subject. A notable feature of this correspondence was the preference almost unanimously declared for a particular type of socket because of the comparative cheapness of its lamp base.

The fact that a socket outlives many lamps does, undoubtedly, as things are now, encourage the use of that particular type of socket which is usable with the least expensive form of lamp base, though the socket in question may not in itself be the best or the cheapest.

This fact would seem clearly to indicate that preliminary to the standardization of the lamp socket must be the standardization of the lamp base.

When scientific fitness, due simplicity and point of lowest cost shall have been attained in regard to the lamp base, then will necessarily result a standard socket.

Following, therefore, this line of argument, and concerning ourselves first with the lamp base, let us, with due reference to its functions, consider what we should demand in a standard lamp base.

The elements involved in this question are three-fold—electrical, mechanical and economical.

Good insulating conditions are of the first importance to guard against leakage or other abnormal action in the wires connecting with the lamp.

Mechanical considerations concern the means by which the base is attached to the lamp—as well as the means by which, when so attached, it couples with the socket — the method of coupling with the latter, while insuring a rigid and unfailing contact, should be such as not to put an undue strain upon the lamp.

Cheapness is, of course, a *sine qua non.*

The death rate in lamps being high, and the base, as a rule, not surviving the lamp, obviously the less value we involve in that base the better.

How many of the present types of lamp base conform to these standard requirements ?

What could well be more inappropriate to the delicate structure and graceful form of the lamp itself than is even the best—or, rather, let us say, the least objectionable — of those appendages with which lamps are now encumbered.

(To be concluded.)

of his warmest friend, Mr. E. D. Adams; and as to the queer coil to

Street Journal recently, and stated that negotiations had been under way

TESLA IN HIS LABORATORY—PORTRAIT OBTAINED BY AN EXPOSURE OF TWO SECONDS TO THE LIGHT OF A SINGLE VACUUM TUBE WITHOUT ELECTRODES, HAVING A VOLUME OF ABOUT 90 CUBIC INCHES, GIVING APPROXIMATELY A LIGHT OF 250 CANDLE-POWER—PHOTOGRAPHED BY TONNELÉ & CO. COPYRIGHTED BY THE "ELECTRICAL REVIEW."

THE COMMERCIAL VALUE OF ACETYLENE GAS AS AN ILLUMINANT.

READ BEFORE THE NATIONAL ELECTRIC LIGHT ASSOCIATION, NEW YORK, MAY 5, BY LOUIS A. FERGUSON.

It is my intention in presenting this paper to treat of acetylene in its commercial aspect as related to the illuminating industry and to attempt no description of its value in the chemical world, as the latter is a field entirely apart from that invaded by this Association and one so comprehensive that it might well be made the subject of another discourse.

The first step in the process of manufacture of acetylene gas is the production of calcium carbide, which is accomplished by the reduction of lime by carbon with the intense heat of the arc in an electric furnace. The chemical equation representing the action is $CAO+3C=CAC2+CO$, the CAO representing the lime, 3C the carbon, CAC2 being the symbol of calcium carbide, and CO the carbonic monoxide. Although several experimenters produced carbide of calcium and carbide of sodium and from these acetylene gas many years ago, the first production of carbide of calcium on anything like a commercial scale was made by Mr. T. L. Willson, at Spray, N. C., while endeavoring to produce the metal calcium in the electric furnace. It was my good fortune to have visited with Mr. Willson his plant at Spray, and there carried on experiments in the manufacture of the carbide of calcium and the production therefrom of acetylene gas, and perhaps a few words in description of the apparatus employed may be of interest to you.

Spray is a beautiful little spot about 25 miles southwest from Danville, Va., and about two miles from Leaksville, N. C. It is reached from Danville by a narrow-gauge road, operated by negroes, the locomotive boiler being fired by wood in true primitive fashion, the roadbed hardly being the equal of the trunk lines between New York and the West. The carbide plant is located alongside of a small stream which has quite a fall at this point, the power of the fall driving a Leffel water-wheel, to which are belted two General Electric Company's 120-kilowatt alternating-current dynamos, built for 60 cycles per second. In Mr. Willson's original work he used a direct-current dynamo of his own construction, but this was abandoned later and the larger alternating-current machines purchased, so as to enable the experiments to be carried on upon a larger scale. It was also imagined that an alternating-current dynamo would give better results, it being claimed that the alternating current would keep the mixture of coke and lime stirred up about the arc. This, of course, was a fallacy, the real value in the use of the alternating-current machines, as compared with the original ones built by Mr. Willson, lying in that, no commutator being required, it was much easier to regulate under the varying conditions of the arc, and there was an entire absence of sparking, which was a destructive feature of the original dynamo. The alternators are built for 1,000 volts, arranged to run in parallel, and transformers are used to bring the pressure to 100 volts. The switchboard for the dynamos is provided with ammeters and voltmeters for each dynamo, so that the output may be accurately determined. From the switchboard large cables, capable of carrying 1,000 amperes, run to each of two furnaces, which are built of brick, the dimensions of the furnace being approximately three feet square and eight feet high. Each furnace is provided with a flue to carry off the gases of reduction. In the floor of each furnace is a carbon plate to which the cables connect, this plate constituting one pole of the arc. The upper carbon for the arc consists of six carbons in one cast-iron holder, each carbon being four inches square in cross-section, and 36 inches long and weighing each 35 pounds. The carbons are raised and lowered by means of a chain winding on a drum operated by a wheel in the dynamo room, so that the energy expended in the production of the arc is maintained constant during the process of manufacture of the calcium carbide. Having thus seen the method of producing the electricity and its application to the electric furnace, we will now pass to the process of manufacture of the carbide. The carbon used in the process at Spray is Pocohontas coke, having a nine per cent ash. The coke is conveyed to a hurricane mill, where it is ground to a fine powder and then put with the lime into a revolving mixer, by which it is thoroughly mixed and prepared for the electric furnace. Theoretically the proportions of lime and carbon necessary for the production of 100 pounds of calcium carbide are $87\frac{1}{2}$ pounds of lime and $56\frac{1}{4}$ pounds of carbon. These combine, according to the formula before mentioned, $CAO + 3C = CAC2 + CO$, $37\frac{1}{2}$ pounds of carbon combining directly with the metal calcium forming calcium carbide, and $18\frac{3}{4}$ pounds combine with the oxygen of the lime, forming carbon monoxide gas, which passes off from the furnace.

Nearly 12 months ago, on May 15, 1895, at Spray, N. C., with the described plant, the writer, together with Mr. George O. Knapp, of Chicago; Mr. T. L. Willson and Major Morehead, of Spray, N. C., carried on a test to show the actual production of calcium carbide per horse-power per day and the volume of acetylene obtainable per pound of carbide. The coke and lime were prepared in the manner described, the mixture containing 800 pounds of air-slaked lime and 390 pounds of powdered coke, making the total weight of mixture 1,190 pounds. Of this mixture 180 pounds were unused, leaving 1,010 pounds which were delivered to the furnace. The test run was for a period of three hours, during which the mixture was fed into the furnace by shovel as required, and the material stoked regularly. The current used varied from 900 amperes to 1,200 amperes as extreme limits, but being kept very regularly at about 1,000 amperes, the voltage varying from 90 to 104 at the extreme and being kept fairly constant at 100 volts. Readings were taken approximately every 10 minutes during the test, and from 23 readings the average showed 1,000 amperes and 100 volts, or an average consumption of energy at the terminals of the furnace of 100 kilowatts during the entire run of three hours.

After the current is turned on and the arc made, the carbide begins to form on the bottom of the furnace under the upper carbons in the shape of a block, and as it forms it is necessary to raise the upper carbons to maintain the proper arc, the current passing from the carbons in the form of the arc to the carbide below, the latter now constituting the other pole of the arc and conducting the current to the plate in the bottom of the furnace. The production of the calcium carbide is by the heat of the electric arc alone and not by electrolysis, the temperature of the arc being in the neighborhood of 3,500 degrees to 4,000 degrees Centigrade, while that of the ordinary smelting furnaces ranges from 1,200 to 1,500 degrees Centigrade.

At the end of the run the current was cut off, the furnace was allowed to cool down and the product and unused material removed and carefully weighed. During the production of the carbide some of the mixture is lost by passing up the chimney with the gases of reduction, which burn with wild sheets of flame, increasing with their hissing the already deafening roar of the immense alternating-current arc. The weight of the calcium carbide actually produced in this test was 139 pounds, the unused material amounting to 607 pounds, to which must be added the water contained in the lime—165 pounds—making the total unused material 772 pounds. The weight of the mixture delivered to the furnace was, as stated before, 1,010 pounds, so that the actual weight of mixture consumed and lost in the process of manufacture of 139 pounds of calcium carbide was 238 pounds. The efficiency of production, therefore, would be the weight of carbide produced divided by the weight of mixture used up, or 139 divided by 238, which gives 58.4 per cent as the efficiency of production.

The next step is to calculate from the results of the tests the amount of carbide produced per kilowatt hour. We have seen that the average value of the energy expended in the production of the carbide was 100 kilowatts, and that we produced 139 pounds of carbide in three hours, or at the rate $46\frac{1}{3}$ pounds per hour. Therefore the carbide produced per kilowatt hour would be $46\frac{1}{3}$ divided by 100, which is $\frac{46}{100}$ pound, or at the rate of 11.12 pounds of carbide per kilowatt per 24-hour day, or 8.3 pounds per horse-power per day of 24 hours. A sample of this carbide produced, weighing 34.1 grammes, was then taken and the acetylene gas formed by adding water, and the gas evolved, measured by means of special apparatus, showed a result of 5.24 cubic feet of acetylene gas per pound of carbide, after making the proper temperature and barometric corrections.

Having thus seen the quantity of calcium carbide produced for each kilowatt hour of energy consumed and the value of the carbide as a producer of acetylene, we will now take up the method of production of acetylene from the carbide and consider some of its properties before determining the cost of production of the carbide.

Acetylene is produced from the calcium carbide merely by the application of water, the action being shown by the equation $CAC2+2H2O=CAOH2O+C2H2$. When the carbide is thus brought in contact with the water the acetylene gas is given off rapidly, and its presence is distinguished by its very pungent odor, somewhat resembling phosphorus. When lighted it burns with a deep yellow flame, and is extremely sooty, but when generated at an even pressure and burned with proper burners, designed for the use of acetylene, it gives a beautiful white light. The acetylene flame so used is exceedingly tenacious, and it is almost impossible to blow it out, which may be considered as an advantage in hotels and other places where rural gentlemen occasionally take up their abode.

A simple method of generating acetylene from the carbide is to take an ordinary chlorine generator and place within some lumps of the carbide, arrange a glass funnel so that water may be admitted to the interior of the generator, connect the generator by means of a rubber tube to a gasometer, the outer tank being partially filled with water; from the gasometer above the water line another tube connects to a gas pipe with a set of burners attached. Water is then poured gradually in small quantities through the funnel into the generator and upon the carbide. The acetylene gas thus generated passes through the tube to the inside of the gasometer and lifts the gas-holder, the position of the latter changing with the quantity of gas generated. The gas is then delivered from the holder by means of the rubber tube to the piping and burners. As the gas is consumed, the holder lowers and a fresh supply is generated by admitting more water through the funnel upon the carbide within the generator.

Another method, which is automatic in its action, is to partially submerge a vessel in water, the vessel being open at the bottom and containing the carbide suspended on a screen in the upper part of the vessel. The gas is then drawn from above the carbide, and as long as it is being used the water remains more or less in contact with the carbide, but as soon as the consumption of gas ceases or diminishes, the pressure of the gas forces the water downward into the lower part of the vessel and away from the carbide, thus causing the generation of the gas to cease. An arrangement similar to this is one proposed for country residences.

Acetylene gas may also be used in its liquid form and is prepared by decomposing the calcium carbide with water in a closed vessel and conducting the generated gas under pressure to a condenser where it liquefies and is then drawn off in tanks for shipment and distribution.

Compared with other gases, acetylene has a very high candle-power. Water gas, which is used in nearly all the large cities of the United States for illuminating gas, when burned at the rate of five cubic feet per hour, gives from 20 to 25 candle-power, while acetylene, when burned at the rate of five cubic feet per hour, gives, according to most observers, 240 candle-power, or approximately 10 times the illumination of water gas.

The temperature of the acetylene flame is low as compared with that of water and coal gas—Professor Lewes placing the temperature of the acetylene flame at 1,000 degrees Centigrade, and the coal gas flame at 1,360 degrees Centigrade. It has been stated by Professor Crafts, of the Massachusetts Institute of Technology, that the true relation of the temperature of the present commercial illuminants, when giving the same candle-power, is: Incandescent light, one; acetylene, three, and water gas, nine, showing that the incandescent lamp gives off the least amount of heat per candle-power, while acetylene gives three times that of the incandescent lamp and one-third that of water gas.

Many experiments have been made by noted scientists and investigators to determine the poisonous qualities of acetylene gas. Guinea pigs, dogs and other small animals have been made martyrs to science and subjected to mixtures containing carbonic oxide, which is the poisonous constituent of ordinary illuminating gas, and after their death their blood has been examined and the amount of carbonic oxide absorbed by the blood determined. Grehant made comparisons of carbonic oxide and acetylene, to determine their relative poisonous qualities, upon dogs. In his experiments he used 20 per cent of oxygen in his mixtures, so as to prevent the animals death by suffocation. He added enough Paris illuminating gas, which contains seven per cent carbonic oxide, so as to give one per cent carbonic oxide in the mixture. The dog showed signs of suffering after three minutes, and in 10 minutes the dog was very sick, and

his blood showed 27 volumes in 100 of carbonic oxide. Another dog was subjected to a mixture containing 80 per cent oxygen and 20 per cent acetylene, and the dog breathed without inconvenience for 35 minutes. Upon examination his blood showed 10 per cent acetylene, less than one-fiftieth of the rate of absorption of carbonic oxide. The mixture contained much more acetylene than that to which a person could be subjected in the use of acetylene as an illuminant, since a leak of the gas would produce an explosion in the room of a dwelling house before the percentage of acetylene mentioned were attained in the atmosphere. Similar experiments were carried on by Brociner, Berthelot and Claude Bernard, and the conclusions of the best authorities indicate that acetylene, when pure, is not poisonous. Berthelot has pointed out that the old method of preparation of acetylene by means of acetylide of copper may contaminate the gas with hydrocyanic acid and thus render it poisonous.

Having seen how the calcium carbide and acetylene are made, and having considered their properties, the question now before us is the cost of producing them. The results of the tests made at Spray, and before described, show that 8.3 pounds of carbide is produced by each electrical horse-power in one day, or .463 pound per kilowatt hour; also, that the efficiency of production was 58.4 per cent. Experience at Spray shows that the carbons used as electrodes last about 70 hours with the same amount of energy as used in this test. The cost of these carbons is $2 each, which approximates six cents per pound, or .18 cent per kilowatt hour. The cost of lime I have put at $5 per ton, and coke at $2.50 per ton, these figures being about the average prices for these materials of good quality, and considerably less than the actual cost of them at Spray. The question of the cost of electrical energy is the all important one, so that I have taken the Niagara price of $20 per electrical horse-power per year of 8,760 hours, considering this to be the lowest commercial price obtainable at the present time, and one which offers no question as to its accuracy, it being one which is absolutely tangible. The estimate is further based on the assumption that the carbide plant is to be operated at full load 24 hours per day and 365 days each year, so that the actual cost per electrical horse-power hour of energy consumed may not exceed $20 divided by 8,760, which is .238 cents, or .317 cents per kilowatt hour. With this data as a basis, the cost of producing one ton of calcium carbide at Niagara Falls, in a plant having ten 200-kilowatt furnaces producing 10 tons of carbide per day, would be as follows:

POWER.		
4,320 kilowatt hours at .317 cents per kilowatt hour		$13.69
MATERIALS.		
2,085 pounds of lime at $5.00 per ton		5.21
1,339 pounds of coke at $2.50 per ton		1.67
CARBONS.		
Carbons for 4,320 kilowatt hours at .18 cent per kilowatt hour		7.78
SUPERVISION AND LABOR.		
Operating two shifts 12 hours each:		
1 superintendent at $5	$5.00	
1 chemist at $4	4.00	
2 foremen at $2.50	5.00	
10 regulating men at $1	10.00	
6 furnace men at $1.50	9.00	
2 grinders at $1.50	3.00	
6 laborers, handling and grinding and mixing at $1.50	9.00	
	$45.00	
Labor per ton, $45 ÷ 10		4.50
Cost of barrels and preparing carbide for shipment		1.00
		$33.85
Interest at six per cent on $25,000, the investment necessary to erect the factory, furnaces, crushing and mixing machinery, apparatus for handling and regulating	$1,500	
Depreciation on $25,000, at 5 per cent	1,250	
Taxes at $10 per 1,000	250	
Insurance at $3 per 1,000	75	.84
	$3,075	

Cost of production at Niagara	$34.69
Freight from Niagara to New York, Philadelphia, Boston or Chicago, at 15 cents per 100 pounds	3.00
	$37.69

This estimate of cost per ton of calcium carbide is intended to represent the cost of manufacture to a large gas company operating in New York, Boston, Philadelphia or Chicago, with its calcium carbide works at Niagara, and whose business would be to produce acetylene from the carbide in the city where the gas is to be used and to distribute it to its customers through its existing mains. It is not intended to represent the cost cleared off its books of any corporation or firm whose sole business would be the manufacture of calcium carbide for the market, for to cover that case we must add to the above estimate the cost of general expense, including administration, royalties and selling expenses, which of necessity would be equal to a large percentage of the factory cost as given. Let us then consider the value of acetylene to the gas companies in large cities. In many articles and circulars treating of this question it has been customary to place the actual cost of acetylene as produced from the carbide, taking the factory cost of the carbide as a basis, against the selling price of illuminating gas at $1 per 1,000 cubic feet. This, of course, is not a fair comparison and is very misleading. Believing that the only fair way to consider the relative value of acetylene and water gas is to compare them upon the basis of cost per candle-power hour in the holder, and assuming that the cost of distribution is the same in each case, I will treat the question on that basis.

We have seen from the results of the tests at Spray that for each pound of carbide we obtained 5.24 cubic feet of acetylene, or 10,500 cubic feet per ton; therefore, the cost per 1,000 cubic feet of acetylene would be one-tenth the cost of one ton of calcium carbide. The candle-power of acetylene being placed at 240 for each five cubic feet of gas, and the candle-power of water gas in the large cities at 25 for each five cubic feet of gas, it will be seen that the candle-power of acetylene is 10 times that of water gas per 1,000 cubic feet, and, therefore, the cost of acetylene giving the same candle-power as water gas would be equivalent to water gas at a cost per 1,000 cubic feet equal to one-one-hundredth of the cost per ton of calcium carbide. For example, if the calcium carbide costs the gas company $100 per ton, then the cost of acetylene gas in the holder will be equivalent to 25 candle-power, water gas costing $1 per 1,000 in the holder.

The present average cost of illuminating gas in the holders of the large gas companies approximates 30 cents per 1,000 cubic feet, while the cost of acetylene gas in the holder, with calcium carbide at $37.69 per ton, would be equivalent, light for light, to illuminating gas at 37$\frac{7}{10}$ cents per 1,000 cubic feet, making the cost per candle-power hour of pure acetylene approximately 20 per cent higher than that of ordinary illuminating gas. If acetylene were mixed with air and distributed, the cost would be less. This has been done in an experimental way, using 60 per cent acetylene and 40 per cent air, but the advisability of attempting to distribute such a mixture through a system of mains in a city for commercial use is exceedingly questionable, owing to the risk of the mixing being improperly done and the quantity of acetylene falling to such a percentage as to form an explosive mixture.

It has been suggested that the cost of distribution, as well as the cost of mains and maintenance, which constitute a large portion of cost in the lighting industry, might be saved by the use of liquid acetylene, put up in cylinders and delivered to the stores, residences and offices, so that the consumer might generate his own gas as required. It appears to the writer that this method is an entirely impracticable and uncommercial one, as there are almost insurmountable objections to be overcome. Neither the average business man nor the occupants of a residence wish to be bothered with the care necessarily attendant upon the use of the cylinders of acetylene. It would be necessary either to have two cylinders ready for service or to have a second one placed in service before the first one was exhausted, and in all probability the busy man would find himself in darkness at the time when he most needed the light, owing to the fact that he had neglected to renew his cylinder. The pressure of the gas in these cylinders is from 600 to 700 pounds, so that it is necessary to use a reducing valve which will give a pressure of one ounce. The same valve which is used with the Pintsch system of railway lighting is employed, but this, in all probability, would not be kept in condition by the ordinary householder or storekeeper, and the consequence would be that the full pressure might be impressed upon the pipes, and in case this were prevented by the use of an auxiliary safety valve, then every failure of the reducing valve would allow all the gas to escape and be lost. The use of acetylene cylinders would increase the danger in case of fire, since the gas would escape should the cylinders become heated, and explosions of the mixture of acetylene gas and air would possibly follow. After considering the many inconveniences and dangers in the use of liquid acetylene in the business and residence district of the large cities, it leads the writer to believe that acetylene, to be commercially successful, must be delivered to the customers in the form of gas through a system of mains, as is done now with ordinary illuminating gas. Liquid acetylene should find a field in the lighting of country estates, railway trains, and for use in carriage, bicycle and locomotive head lamps, and in isolated places where distribution by mains is not possible.

When acetylene was first brought forward to be used commercially, it was expected that the gas companies might still maintain their existing gasworks and use acetylene to enrich their gas and furnish a 25-candle-power flame as formerly, but at a much less cost. Experiments have shown, however, that, although coal gas may be enriched by acetylene, water gas is not susceptible to enrichment by it. Water gas, which is furnished in nearly all the large cities, has little illuminating power of its own, is now treated with petroleum, and it is only when enriched to a certain candle-power that acetylene may be mixed with it without losing its candle-power, so that we can not, as at first supposed, substitute acetylene for petroleum and use it economically as an enricher of low candle-power water gas.

It has been suggested that the manufacture of calcium carbide might be carried on by the central station electric lighting companies as a by product, furnishing the energy necessary for its production during the hours of light load upon the lighting system, thus bringing the load curve of the station nearer to a straight line and thereby improving the economy of the station operation. It will be readily seen from the figures given in the estimate of the cost of producing the carbide that the cost of power is a very important factor, and if we increase the cost given, of $20 per horse-power per year, we will correspondingly increase the cost of the carbide. From experience with the cost of operation of the largest central lighting stations in this country, the writer can safely state that the absolute cost of fuel alone in the most economically operated lighting station of the most modern type of multiple expansion condensing plant averages .3 of one per cent per kilowatt hour, or approximately $20 per horse-power per year continuous service, while the total cost of generation in the station would average over double that amount. In the average of the large central stations the generating cost at the switchboard, without distribution and general expenses, approximates one cent per kilowatt hour, which is about $65 per horse-power per year, and in the smaller stations using steam, double that amount. It is obvious then that we may not hope to use our present central stations during minimum hours for the manufacture of calcium carbide as a by-product while the cost of power in our stations remains as it is at present, and the amount of power required for the production of carbide so excessive as the cost of its production by the central station would be prohibitive. It would be much better and more economical for the central station manager to sell his electrical energy through the incandescent or arc lamp at the same price per kilowatt hour than to use the energy for the production of carbide, since the cost per candle-power hour would be less when the electrical energy is converted into light directly through the incandescent and arc lamps than through calcium carbide and pure acetylene, assuming the cost of distribution and general expense to be the same in each case. Take, for example, carbide at $40 per ton, which means 40 cents cost per 5,000 candle-power hours of acetylene gas in the holder, or 125 candle-power hours for one cent. Compare with this electrical energy at the switchboard at two cents per kilowatt hour. For each kilowatt hour generated we obtain twenty 50-watt incandescent lamps, each giving 16 candle-power, making a total of 320 candle-power hours per kilowatt hour, or 160 candle-power hours for one cent, which is 28 per cent more candle-power for the same expenditure of money by the use of the incandescent lamp directly as a converter of electrical energy into light, as against the conversion by means of carbide of calcium and acetylene.

If we take the case of the arc lamp and add to the cost of the electrical energy 1.5 cent per kilowatt hour for carbons, trimming and lamp repairs, making the total cost 3.5 cents per kilowatt hour, we find it still more advantageous. Assuming a 500-watt arc lamp gives 1,000 candle-power, we have 2,000 candle-power hours per kilowatt hour, or 575 candle-power hours for one cent, which is 4.6 times the illumination for the same money as compared with pure acetylene gas. Taking the cost per kilowatt hour at the switchboard in the large central stations, we obtain 320 candle-power hours for one cent, which is 156 per cent more candle-power for the same expenditure of money by the use of the incandescent lamp directly as a converter of electrical energy into light, as against the conversion by means of carbide of calcium and acetylene. By means of the arc lamp, on the basis of cost of one cent per kilowatt hour for electrical energy and 1.5 cent per kilowatt hour for carbons, trimming and lamp repairs, we obtain 800 candle-power for one cent, or 6.4 times the illumination for

Special Electric Light Convention Supplement

ELECTRICAL REVIEW

NEW YORK, MAY 20, 1896.

SOME ACCOUNT OF THE EVOLUTION OF THE INDUCTOR ALTERNATOR.

(*Continued from page 8, Supplement, May 13, 1896.*)

has become a matter of course. Yet, in respect to the steadiness of the flux, this machine is distinctly retrogressive and decidedly inferior to Wheatstone's second design. Holmes intended the machine for electric lighting, but I am not aware of its ever having come into practical use.

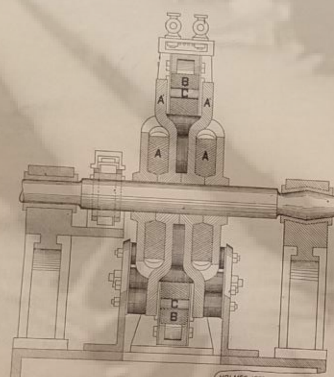


FIG. 9

HOLMES, 1868.
A'A' INDUCTOR POLES.
A.A. EXCITING COILS.
B.B. INDUCED COILS.
C.C. KEEPERS.

Gramme's invention came near putting an end to work on inductors, as, indeed, to work on alternators of any kind. Yet, in the time intervening between the introduction of the Gramme machine and the resurgescence of the alternator, provoked by the introduction of the modern transformer, C. F. Varley* designed an inductor, Figures 12 and 13, which deserves mention for its novelty. The induced coils are subject to the influence of two inducing magnets which tend to develop opposite fluxes through them. These

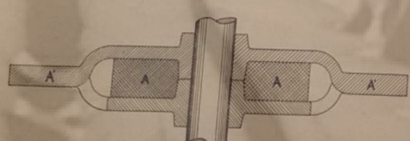


FIG. 10

HOLMES, 1868
A'A' INDUCTOR POLES.
A.A. EXCITING COIL.

magnets are alternately short-circuited by the keepers, and, in consequence, the flux through the induced coils is alternated by arranging the keepers so that they begin to short-circuit one inducing magnet before entirely open-circuiting the other; the flux in the inducing magnets is kept more or less constant. In this same year, Paul Jablochkoff took out an English patent for an inductor alternator. It is of the single induced-coil type; but were it not for the inventor's great fame, considering the date, it would not be worth attention.

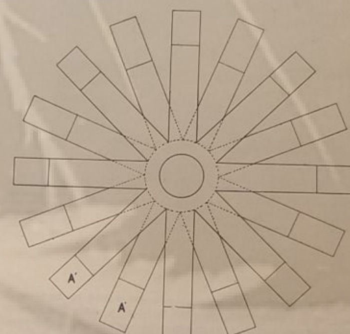


FIG. 11

HOLMES, 1868.
A'A' INDUCTOR POLES.

Even the best of these early inductors must have had vast iron losses. In most cases there was no thought of preventing them, and, when preventive

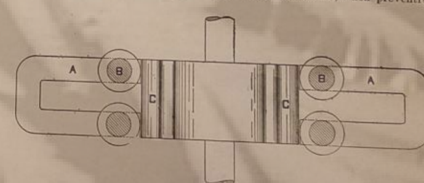


FIG. 12

C.F. VARLEY, 1877.
A.A. INDUCING MAGNETS.
B.B. INDUCED COILS.
C.C. KEEPERS.

measures were adopted, they were entirely inadequate. The mass of iron subject to magnetic change was always, relatively to the size of the machine,

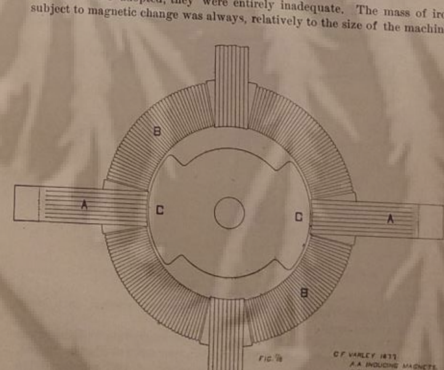


FIG. 13

C.F. VARLEY, 1877.
A.A. INDUCING MAGNETS.
B.B. INDUCED COILS.
C.C. KEEPERS.

enormous, thus necessarily increasing the hysteresis loss; while no sufficient provision appears to have been made for the prevention of Foucault currents. The machine of Klimenko, exhibited at Vienna, which required more power

---

* The figures of C. F. Varley's machine were made entirely from description. They may be quite different from those in his patent.

to drive it when running light than when loaded, was not, I think, exceptional.

In 1887, Mordey cut the Gordian knot by entirely suppressing the iron in the induced portion of the machine. The highly and deservedly successful machine that bears his name is shown in Figures 15 and 16.

There is a central core surrounded by the exciting coil A. From each end of this core projects a set of radial polar arms, which are recurved so as almost to meet one another. In the space left free are mounted the thin induced coils BB in a circle. The induced coils are wound in the plane of this circle, and are in number twice the polar faces on one side. The induced coils are fixed and the inducing magnet revolves. The exciting coil turns with the core, but this is electrically immaterial, and the results would be the same were it at rest. Obviously, the total reluctance of the magnetic circuit is the same, no matter what the position of the inductor. Change of flux in the iron is due only to armature reaction, and it gives rise to iron losses only because of its space variations. With a low armature reaction, such losses will be extremely small.

Mordey's success, instead of putting an end to attempts to build inductors with iron in the induced portions, gave rise to a new series of efforts. Indeed, Mordey himself was foremost. His English patent of 1887, relating to the coreless armature machine, also described a machine with cores, and in subsequent patents he describes the machines shown in Figures 17, 18, 19 and 20.

These machines have not come into use, and, presumably, they are not as satisfactory as the coreless machine. Yet they show a marked advance when compared with the older machines. The use of the short-circuiting pieces C′, as well as the bridges C, tends to make the flux constant in amount and to restrict the magnetic changes to the induced portions of the machine. The iron subject to magnetic change is also properly laminated to prevent Foucault currents. The most obvious fault in the designs is that the mass of iron in the induced portions is large, and that all of it is subject to hysteresis loss.

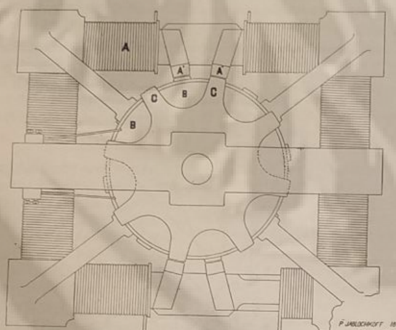


FIG. 14.

P. JABLOCHKOFF 1877.
A A′ INDUCTOR POLES.
A EXCITING COILS.
B B INDUCED COIL.
C C KEEPER.

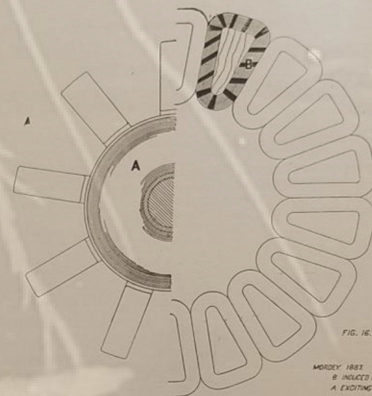


FIG. 16.

MORDEY 1887.
B INDUCED COILS
A EXCITING COIL.

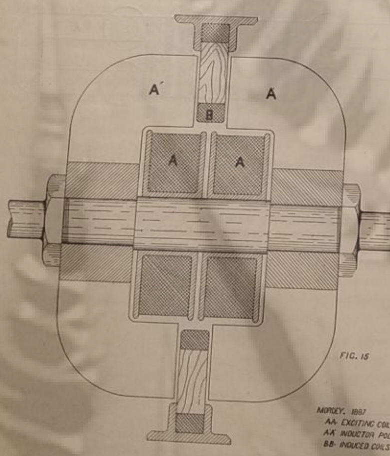


FIG. 15

MORDEY. 1887
AA. EXCITING COILS.
A A′ INDUCTOR POLES.
BB. INDUCED COILS.

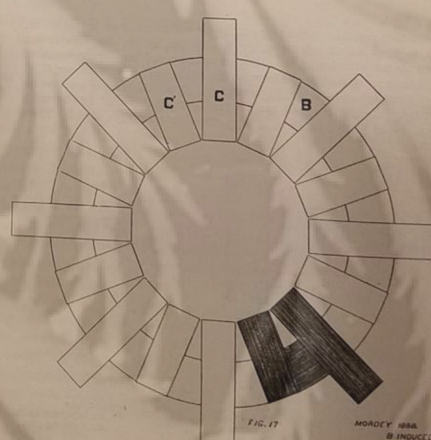


FIG. 17

MORDEY 1888.
B INDUCED COIL
C.C. KEEPERS.

In passing, it may be worth while to note one peculiarity of single induced coil machines like the earlier of the Mordey designs. With any given frequency, the output is independent of the speed; or, in other words, the only limit to reduction of speed is the possibility of further sub-dividing the poles. For, with the number of poles increased N times, the total change of flux takes place with 1/Nth the angular motion. This remarkable property may some day bring about the introduction of machines of this class for direct connection to very slow-speed engines.

The Kingdon machine, Figure 21, is a modernized Henley machine. The exciting and induced coils are wound on the alternate polar projections, and the magnetic connections between the inducing and induced cores are alternately reversed by the rotating keepers C. The whole of the iron in the machine appears to be subject to hysteresis loss. Foucault currents are checked in the usual manner by lamination. In this machine, if the induced coils are so wound that they may be worked in parallel, it is possible to

reduce the iron losses in proportion to the load by cutting out both inducing and induced coils in the same degree. I hardly think that this advantage is sufficient to countervail, having the hysteresis loss too high to begin with. A few of these machines were put into practical use, but I think not many.

The machine designed by Rankin Kennedy in 1890 is a twinned form of the Mordey, shown in Figures 17 and 18, with the short-circuiting pieces C left and out of harm's way, and the only moving pieces in the machine are the shaft and the single star-shaped inductor. The adaptation of the machine to single, two or three-phase working is merely a matter of the number and grouping of the induced coils. The duplication of the exciting coil is not, I think, to be considered an improvement. High hopes were entertained of the future of this machine. Of the causes of their frustration it is not for me to speak.

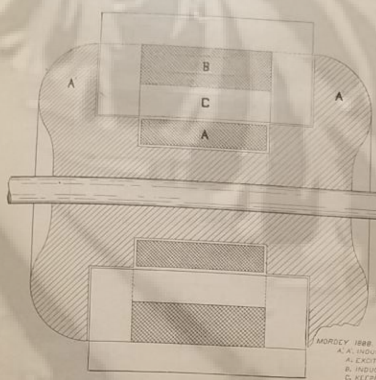


FIG. 18

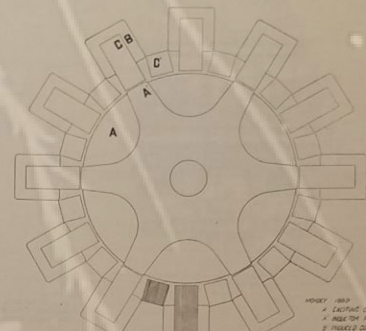


FIG. 20

out. This necessitates the lamination of the whole of the iron, and subjects it all to hysteresis loss. The twins are so arranged that the induced electromotive forces in the inducing coils are in opposition, so as to prevent the development of alternating currents in the inducing circuit. The machine has not, I think, been practically introduced, and in my judgment it is less fitted for use than its prototype.

The modern machines thus far described lend themselves badly to polyphase working. This is true even of the standard Mordey, while as to the others, adaptation to polyphase means practically duplication or triplication of the whole machine. As polyphase machines, they are merely mechanical combinations of single phase machines. A machine adapted directly to polyphase working, on the other hand, regulates more closely and is more efficient as a polyphase than as a single-phase machine. The machines that follow are all suitable for polyphase.

The first of them, Figures 22 and 23, is due to one of the masters of our profession in this country, and would even on this account alone be worthy of attention. But mechanically, in the robustness and simplicity of design, it seems well in advance of its predecessors. The induced coils are well secured

The operation of the Pyke and Harris machine will be clear from the drawings, Figures 24 and 25. The machine consists of a pot magnet with a central core. At the bottom of the pot lies the inducing coil A. The lip of the pot and the core carry inwardly and outwardly projecting laminated polar extensions which support the induced coils B. Between these polar extensions move the rotary laminated keepers C. What I have called keepers here, on account of their appearance and size, really correspond to the inductor in the Thomson machine, and in that which follows, for they normally constitute that portion of the machine in which the flux is most invariable. There is no reason why a machine of this form should not be all right electrically if well designed. Mechanically, however, it seems to sacrifice that very simplicity which makes inductors desirable.

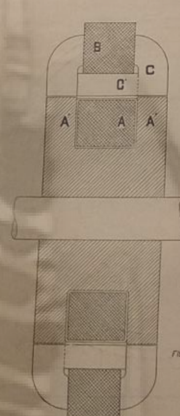


FIG. 19

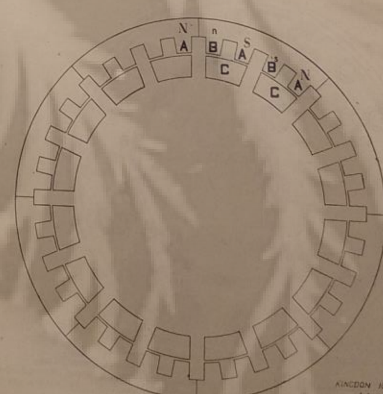


FIG. 21

I now come to the machine with which I am best acquainted, and in whose designing I took part. For these reasons I may be pardoned for going more into detail in the description, since they enable me to give more information. Coming after that of so many able engineers, it is scarcely to be expected that the work of my colleagues and myself should result in any startling change in form, and, in fact, our improvements are not such as to catch the eye.

They, however, have made the induction alternator with iron-cored armature a success; so much so, that I have no hesitation in saying that the inductor is not only the alternator of to-morrow, but that it is the alternator of to-day.

Figures 26 and 27 show clearly the construction of the machine. The rotary inductor is a cylindrical steel casting with outwardly projecting, laminated pole pieces at either end. The armature consists of two rings connected by wrought-iron tie bars. The induced coils are sunk below the surface in grooves in the armature rings, and the stationary exciting coil lies in the

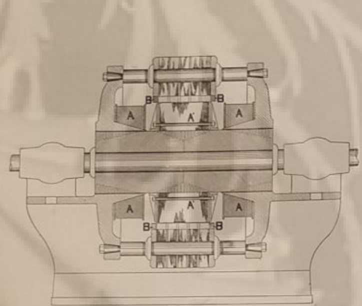


FIG. 22

THOMSON 1890.
A'A' INDUCTOR POLES.
A.A. EXCITING COILS.
B.B. INDUCED COILS.

space between the pole-pieces and the armature rings. The machine is very effectively ventilated by means of openings in the middle of the inductor under the exciting coil and the spaces between the tie bars. The exciting coil itself is protected from injury by a massive hollow ring of cast copper, inside which it is wound.

I have already called attention to the importance of keeping the flux constant in the inductor, so as to avoid hysteresis and Foucault-current losses therein. The only thing tending to disturb the inductor flux is the varying reluctance caused by change in the relative position of the armature slots and the inductor poles. To keep this at a minimum is the chief reason for preferring a double wreath of induced coils to a single one. Mechanical interruption at both ends is necessary in either case, and it is wise to take advantage of it in distributing the induced coils. With the same amount of

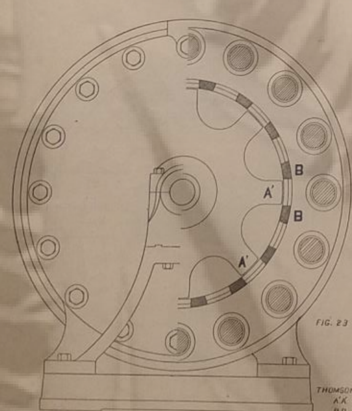


FIG. 23

THOMSON 1890.
A'A' INDUCTOR POLES.
B.B. INDUCED COILS.

wire, the space variation of reluctance is much less when both air-gaps are utilized than when only one is, and, at the same time, the regulation of the machine is better. As complete lamination of the body of the inductor is difficult, even a slight change of flux is to be sedulously avoided. Lamination of the pole-pieces is necessary, even with constant flux, as the slots necessarily change its distribution.

But, even with the flux through the inductor constant, the difficulties are by no means surmounted. A large mass of iron in the armature is a necessity of the construction, and the losses in this way may be such as to make the machines practically inoperative. Only thorough lamination would put an end to the Foucault losses, and thorough lamination is, for structural reasons, out of the question. Another solution is imposed. Now, when the flux is constant in the inductor, it is obvious that in amount it must also be constant

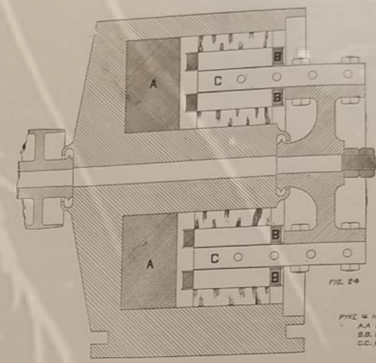


FIG. 24

PYKE & HARRIS. 1892.
A.A. EXCITING COILS.
B.B. INDUCED COILS.
C.C. KEEPERS.

in the armature. It but shifts in position without altering in magnitude. But to give rise to the electromotive force in the induced coils, it is unnecessary that the shift should take place throughout the mass of the armature. It is necessary only that the shift should take place through the coils; that is, to the depth to which the coils are embedded. The problem is, therefore, to combine a steady flux in the center of the armature with a shifting flux in the armature faces; or, in other words, the distribution of the flux in the middle of the armature must be independent of the points in the faces at which the flux enters. Stated in this way, an analogy with the conditions of electrical distribution in parallel is suggested, and this points to the solution. Consider for a moment the two laminated rings as electrical mains and the

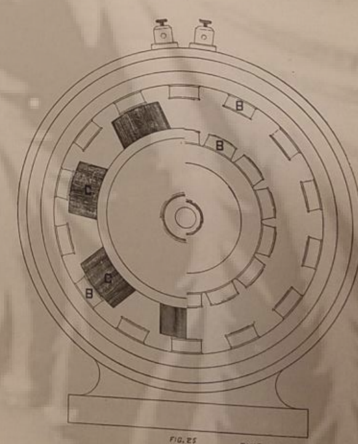


FIG. 25

PYKE & HARRIS. 1892.
B.B. INDUCED COILS.
C.C. KEEPERS.

tie bars as translating devices. Then, if the two mains be of low and the translating devices of high resistance, the current through the translating devices will be substantially independent of the points of attachment of the feeders—the analogues of the inductor poles. Similarly, if the reluctance in the direction of the lamination be low in comparison with that in the

direction of the tie bars, the magnetic flux in each bar will be constant, no matter what the position of the inductor poles. In this manner, the change of flux is confined to a small portion of the armature iron, which may be thoroughly laminated, and thus Foucault-current losses are suppressed and hysteresis losses reduced to a minimum. It thus becomes possible to use in the armature any quantity and form of iron demanded for structural reasons.

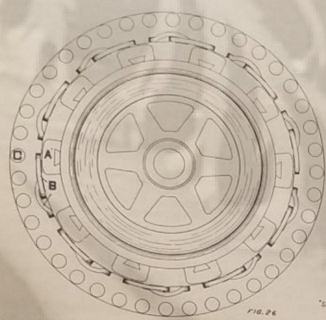


FIG. 26

"S.K.C." 1893
A INDUCTOR POLES
B INDUCED COILS
C KEEPERS.

It will be noticed that the inductor poles are curved in a special manner. This is done to make the electromotive force curve as nearly as possible a sine curve. You will remember that some time ago much space was given up in the electrical journals to a controversy as to the best form of electromotive force wave. Nearly every form of wave found some advocate for some purpose, but somehow the sine wave seemed always to be second best. As we are building machines for general service, we are entirely satisfied with that curve which is second best for each special purpose, believing it to be in consequence the best for general distribution work.

The heavy copper bobbin surrounding the exciting coil, besides being a mechanical protection for the coil, is also of use in that it prevents the development of an excessive electromotive force in either exciting or induced coils, if the exciting circuit should be accidentally broken. It resists very powerfully any sudden change of flux.

An important advantage of all stationary induced-coil machines, and, of course, therefore, of inductors, is the possibility of regulating separate cir-

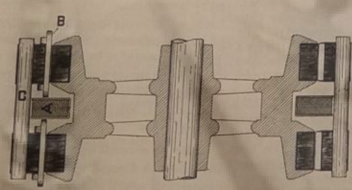


FIG. 27

"S.K.C." 1893
A EXCITING COIL
A' INDUCTOR POLES
B INDUCED COILS
C KEEPERS.

cuits or feeders with little or no auxiliary apparatus. Since it is possible to tap the armature coils at any point, any desired electromotive force between zero and the maximum may be obtained for one circuit without altering the excitation, and, consequently, without interfering with the electromotive force of any other circuit. Circuits or feeders having different drops may thus be provided for. Figures 28 and 29 show two methods of operation. The coils AA in the first are the main inducing coils, giving the electromotive force necessary for all circuits or for the mains in a feeder and main system. BB are the auxiliary or regulating coils.

The number of the regulating coils in circuit is controlled by the switches CC. The diagram shows only two circuits; but, of course, any number may be branched on, each with its own regulating switch. This method is the simpler for the operation of only one or two machines. With a larger

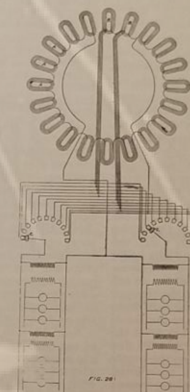


FIG. 28

number of machines I would recommend the method shown in Figure 29, as it gives simpler switch connections. In this method, the auxiliary induced coils do not act directly upon the circuits, but only through the intermediary of the auto-converters D. This method of regulation has the advantage over the ordinary "booster" system that the auto-converter D has, for the same regulation needs to be only one-half the size of the corresponding "booster," and it is, besides, more efficient. The adoption of either method secures the same

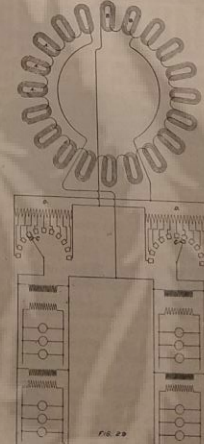


FIG. 29

flexibility and ease of control of the individual circuits as if a separate machine were used to feed each one, while, at the same time, we get the lower first cost and greater economy of operation of large machines.

STEAM BOILERS: THEIR EQUIPMENT AND MANAGEMENT.

READ BEFORE THE NATIONAL ELECTRIC LIGHT ASSOCIATION, MAY 7, 1896, BY ALBERT A. CARY.

One of the first considerations to be taken up in designing a new boiler plant is found in the question, "What style of boiler is best adapted to our work?" And after this is answered the other question following closely at its heels is, "Are our available funds sufficient to equip this plant with the chosen form of boiler?" Unfortunately, we find by no means a small percentage of prospective steam users asking these questions in the reverse order, and it is due largely to this fact that we find so many tank-makers in the boiler business, so many coal companies flourishing and growing rich at the steam-users expense, so many boiler insurance companies springing up in every section of the country, to say nothing of the profits of the owner of the boiler, which unnecessarily go to keeping the boiler plant in repair and the coal pile replenished. All these troubles do not result from the doings of the "penny wise, pound foolish" man, but there is also a large percentage of the plants erected where ignorance has been the partner of the designer, and we find the outsiders again reaping the profits which properly belong to the victim.

After many years of close contact with steam-users, I have been led to believe that there is no branch in engineering in which more money is foolishly spent, due to the ignorance of the purchasers, than in steam plants, especially those of small size, say from 300 horse-power down.

I have met many manufacturers who are bright, practical, mechanical men, understanding their business in all its details to a degree that commands your admiration, but when it comes to their steam plant, alas, how little they know, although they think, in their own conceit, that they have mastered this "easy subject" way back in their early days and there is nothing left for them to bother themselves with, and nine times out of ten you will hear them boast that their steam plant is a model one in every respect.

In these very plants you often will find smoky chimneys painting the whole neighborhood with foulness, and not a single attempt is made to stop this. You will find many of these boilers filling up with scale, and this is calmly accepted as a necessary evil. You will find miserable firemen wasting coal, and so I might continue this list of unnecessary evils to a considerable length.

In many of this class of plants no effort is made to determine the actual amount of power used, unless by a very popular process called guessing, and this extremely delicate operation is often left to the man who opens the throttle or shovels the coal under the boiler. He, naturally, wishing to show up in the best possible light, often decides upon a pretty high figure which I have on more than one occasion been forced to lower by a large percentage after conducting a careful test. This man, after finally deciding upon the amount of power he thinks the plant is taking, carries these figures to "the boss." Then follows a lot of profound figuring, and finally it is shown that the steam plant is wonderfully efficient, and often the boiler is found to be evaporating something like 16 pounds of water to a pound of coal, and all of the owners and attendants of the plants in the neighborhood are made envious over these wonderful results.

From such false results as these, the excessive amounts of coal used in these plants is considered a remarkably low consumption for the "very large amount of power developed," as has been determined by the guessing process. The owner settles back perfectly contented with his steam plant and then all progress and improvements stop. His self-satisfied ignorance and boasting finally induces his neighbor (who knows just as much about steam plants as he does) to put a similar plant in some new mill he is building, and so the installation of inferior steam plants continues and becomes almost epidemic.

There is no one who enjoys and profits more by this state of affairs than the coal dealer. He stocks up with all kinds of coal, good, bad and indifferent. He furnishes the class of steam users we have described with anything and everything in the coal line and gets good prices for what he is selling, but this is not the condition of affairs in up-to-date plants, designed and managed by competent engineers. The coal dealer knows that in these plants the amount of coal used and water evaporated is continuously kept account of, and as an inferior coal will evaporate less water than the good, pound for pound, he knows that a delivery of inferior coal will be detected at once and it will cost him a customer if he is not very careful.

Now, to return to the equipment of our new boiler plant, and consider the matter of selecting the best boiler adapted to our use. This is a somewhat weighty question, and unless we are thoroughly posted in the practice of to-day, we had much better hire a competent engineer to make this decision for us, and the money paid to him will, in the end, be found to be an excellent investment.

There is probably no branch of trade employing abler men to discuss the merits of their output and sell their product than is found in the boiler business, and I am really forced to pity the inexperienced purchaser who is not perfectly capable of forming his own individual opinion of the relative merits of the various boilers offered to him and their adaptation to his use. Such a man is very apt to be influenced by the words of the smoothest talker, or the one who tells him his "story" last, and in the end he is pretty sure to make a serious mistake by selecting a boiler very poorly adapted to the service it is intended for, or one far inferior to the boiler he started out to buy.

I am sure that those present who have passed through this ordeal will bear me out in these statements, and this merely emphasizes what I have said before; that is, that if you were not thoroughly competent to select one of the many boilers, hire a good, able mechanical engineer, one experienced in boiler practice, and let him decide for you. I do not mean by this that you want a man who knows simply one make of boiler and uses it for every plant for which he is retained. There are too many men of this kind, unfortunately, and by the narrowness of their decision they prove that they are incapable of judging the respective merits of the various steam boilers offered to them. Such men are apt to make you pay exorbitant prices, or else they are apt to give you something you really do not want, and they prove in this way that they are not worth their hire. In selecting the best type of boilers for a certain specific use, the conditions under which it is to be run, of course, must be considered. To cite a few examples: Let us first take up the case of a boiler to be used in a rolling-mill, where we find a long line of connected rolls running across the middle of the mill, with a large reversing engine connected at one end, in most cases by gearing. This engine, we generally find, has a cylinder of large diameter and a comparatively short stroke. We find lacking some of those refinements in valve gear which promote economy in the engines used for other purposes, and, in consequence, we find these engines calling for from 50 pounds of steam upward for each horse-power developed. These engines are frequently started up with the full load on, taking steam about the entire length of their stroke, and making the severest kind of a demand on the boiler for a supply of steam which is required to furnish this large amount in a very short space of time. In such a case as this the boiler must be of such design that it will deliver a very large quantity of steam in a very short space of time, and this may be accomplished in several ways; viz., first, by having a boiler with an abnormally large steam space; second, by having a boiler with a large water capacity and a moderate-sized steam capacity; third, by having large hot-water storage cylinders to supplement the quantity of water held in the boiler; fourth, by running the boiler at a steam pressure several times higher than that used at the engine and delivering the steam through a very large reducing valve, which reduces and delivers the steam from the high pressure to the pressure required at the engine.

(To be continued.)

Graphite in Electrical Industries.

Graphite, which is one of the forms of carbon, and more generally known as plumbago or black lead, has come to be an important factor in electrical industries. It is a graphite crucible which is used for electrical smelting, and it is a graphite pencil or rod which is used as an electrode in the process of electrical smelting. It is graphite pulverized to an impalpable powder that is used in electrolytic work by the copper smelters. Pure flake graphite is also used for lubricating cylinders and bearings of engines and dynamos, and the same material also forms the pigment for protective paints for trolley poles, electric light poles and roofs of dynamo plants and trolley car sheds. Graphite would therefore seem to be a very important factor in electrical industries. During the last year or two the demand has very greatly increased for graphite resistance rods. Unlike German silver, it is not necessary to take into account the factor of quantity. For instance, a six-inch rod one-fourth inch in diameter may be made to have one ohm resistance or 10 ohms, or 1,000 ohms, or, in fact, almost any resistance that the electrician may require. The only reason for changing the dimensions of such rod would be either convenience or for radiating the heat when it is necessary to carry a current of considerable quantity at high resistance. The Joseph Dixon Crucible Company, of Jersey City, N. J., which was the originator of the graphite industry, and is now the most extensive miner, manufacturer and importer of graphite, has paid particular attention to the requirements of electrical engineers and is supplying the electrical industries with large quantities of material.

Niagara Falls Calcium Carbide Plant Started.

The plant of the Acetylene Light, Heat and Power Company was started at Niagara Falls, N. Y., on April 27, in the manufacture of calcium carbide. This factory is located on the lands of the Niagara Falls Power Company, and at present 1,000 horse-power is used.

KINDRED INTERESTS

Mr. Frank H. Stewart, of Frank H. Stewart & Company, the supply house, of Philadelphia, has been in New York several days this week.

The Helios Electric Company, Philadelphia, has recently issued a well prepared pamphlet illustrating the Helios standard arc lamp for direct and alternating currents.

The offices of the Valentine-Clark Company, of Chicago, dealers in poles for overhead wiring, have been moved from the Rookery to 804–5 Gaff Building, 236 La Salle street, Chicago, Ill.

J. A. Le Roy announces that he is prepared to manufacture an improved aluminum fluoroscope and also Roentgen-ray apparatus complete. Mr. Le Roy is located at 143 East Thirteenth street, New York.

W. R. Ostrander & Company, manufacturers of electric and speaking-tube goods, have removed to No. 22 Dey street, New York city. This company is one of the oldest in the business and very widely and popularly known.

The Beacon Lamp Company, of Boston, Mass., the well known makers of incandescent lamps, are manufacturing high-grade X-ray tubes. Prospective purchasers of these tubes will find it to their interest to communicate with the Beacon company.

The Grutting electric soldering iron and curling-iron heaters are rapidly becoming recognized as standard goods. The Electric Appliance Company, of Chicago, as general western agents, are carrying a stock of these goods, which are meeting with ready sale.

The Electric Appliance Company's complimentary duplicate order book advertising scheme has proven to be a big success and the books are much appreciated by their customers. The Electric Appliance Company, Chicago, still have a number of books left, which will be sent free on application.

The new watch-case receiver of De Veau & Company, New York, is receiving many words of praise from users. These practical telephone men are satisfied that they have the best thing of the kind that can be made. Their new catalogue is now ready for distribution, and every one interested in telephones should send for it.

The Goubert Manufacturing Company has opened a Western office at 203 Monadnock block, Chicago, Ill. These western headquarters are required through the increase of business for the Goubert company in that section of the country. The new offices will be in charge of Mr. E. Webster, who is well known in engineering circles and is an expert in the matter of steam appliances. He was for many years with the Stillwell-Bierce and Smith-Vaile companies, of Dayton, Ohio.

THE OLDEST ELECTRICAL WEEKLY IN THE UNITED STATES.

ILLUSTRATED ELECTRICAL REVIEW

A Journal of Scientific and Electrical Progress.

Vol. XXIX.—No. 7. NEW YORK, WEDNESDAY, AUGUST 12, 1896. TEN CENTS A COPY. THREE DOLLARS A YEAR.

ILLUSTRATED
ELECTRICAL REVIEW
A Journal of Scientific and Electrical Progress.

VOL. 29. No. 7. WEEKLY. NEW YORK, WEDNESDAY, AUGUST 12, 1896. $3 PER ANNUM. Single Copies, 10 Cents.

Entered at Post Office, New York, as Mail Matter of the Second Class.

VIEWS, NEWS AND INTERVIEWS.

A conductor on a trolley car in a Rhode Island town, when asked how the road was doing, replied that "business was badder than it were a year ago." It seems that the Boston atmosphere of good English does not extend as far as Rhode Island.

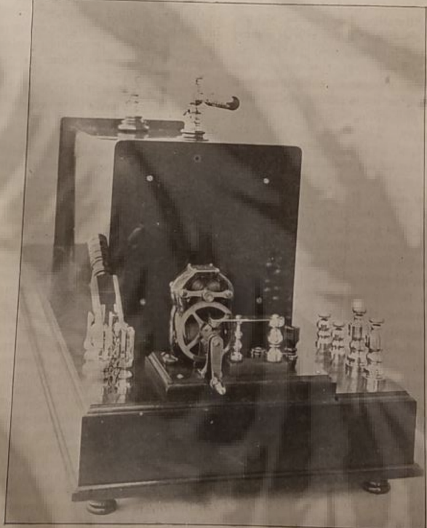
It was on a Summit street trailer, says a Kansas City paper, and the young mother was absent-mindedly gazing on a far-off blue-capped height and carelessly toying with a pink-tinted transfer check in her right hand. The baby had asked for the pretty ticket, but the mother's thoughts were busy elsewhere. She kept on looking out over the landscape, evidently in a brown study. "Fares, please!" It was the conductor. The mother came back to the present tense with a jump. "I paid my fare once." "No, mam, you didn't, beggin' your pardin'." "Yes I did. I had a trans——." Just then the baby began to gag and grow black in the face. And not only black, but all about her little mouth were remarkable variegations in shades of pink. The transfer ticket had returned to the pulp from which it was made. The mother scooped out what was left of it from baby's mouth, thumped the little one's back to aid it in recovering its breath, and then turned a very red face toward the conductor in mute inquiry as to what was to be done. The conductor said never a word. He merely held out his hand. "Well, I won't pay again. I—I—I'll walk first." The conductor gave the gripman one bell. All the passengers looked their sympathy as the mother and the variegated little one left the car.

In last week's ELECTRICAL REVIEW appeared an article credited to the Philadelphia *Times*, describing Mr. Tapley W. Young's apparatus for thawing out oil wells. In the last paragraph of the article it is stated that the apparatus is controlled by the Standard Oil Company. Mr. Young writes that this is not a fact, but that otherwise the article gives a correct description of his device.

A foreign exchange says that King Menelik, of Abyssinia, has commissioned a Belgian engineer to erect a telegraph and telephone system in Abyssinia, which is to connect all the more important points in the country. Each telegraph station is to have a telephone, and the more important are to be connected with the king's residence.

It has been recently stated on good authority, says London *Lightning*, that there are at work or under construction in Canada 36 electric street railroads, with a total length of nearly 600 miles. No less than 750 motor cars are in use or building, and the sum invested in the various undertakings is a little over four millions sterling. England in the meantime is just beginning to wake up, rub her eyes, and wonder whether the horse-tram could really be improved upon, and whether ½*d.* a mile running costs, with speed, cleanliness and comfort, are, on the whole, preferable to 7*d.* a mile running costs, polluted streets, frowsy 'buses, the traveling powers of a gouty tortoise and the horrors of cruelty to animals. "But," says the dear old grandmother of nations, "we might hurt somebody, or frighten a dog; and then, after all, we have got on without these things so far," and she dozes again.

It is said that the water power at Fairfield, Me., will be used to develop electric current. About 2,000 horse-power is available.



EDWARDS'S NEW INDUCTION COIL.

Edwards's New Induction Coil.

The new 12-inch Ruhmkorff induction coils which are being constructed by Messrs. Edwards & Company, of 144th street and Fourth avenue, New York city, are an important addition to the X-ray apparatus now on the market. This coil has features for which excellent results are claimed. All the fittings are of bronze, and the dimensions are as follows: Width, 15½ inches; length, 3 feet 4 inches; height, 20 inches.

With the view of reducing the potential difference between adjacent layers and sections of wire, the secondary winding is divided by rubber disks into 12 sections, and double-covered silk wire is used to insure perfect insulation in the highest degree. The interrupter consists of a small electric motor which can be operated with facility by hand.

The platinum contact points are so arranged that they can be readily renewed and are unusually heavy. The apparatus is mounted in a heavy, hard-rubber case, on a polished mahogany base, and weighs approximately 175 pounds. The illustration herewith shows the general construction of the apparatus.

A New Illuminant.

The London correspondent of the Manchester *Courier* publishes a remarkable account of a new illuminant, which, if all that is said of it is true, will push both gas and electric light very hard. For its production no machinery is required save that contained in a portable lamp neither larger nor heavier than is used with colza oil or paraffine. This lamp, it is declared, generates its own gas. The substance employed is at present a secret, jealously guarded by some inventive Italians. The cost is declared to be at most one-fifth of that of ordinary gas, and the resultant light is nearly as bright as the electric light and much whiter. A single lamp floods a large room with light. The apparatus can be carried about as easily as a candlestick and seems both clean and odorless.

ELECTRICAL REVIEW

Times Building, 41 Park Row,
P. O. Box 2339. NEW YORK.

EDITOR:
CHARLES W. PRICE.

ASSOCIATE EDITOR:
STEPHEN L. COLES.

REGISTERED CABLE ADDRESS:
"ELECTVIEW," NEW YORK.

1546 "CORTLANDT," TELEPHONE CALL.

SUBSCRIPTION TO THE
ELECTRICAL REVIEW.

One Year, United States and Canada, - $3.00
One Year, Foreign Countries, - - 6.00
Single Copy, - - - - - - .10

Copies can only be supplied for one year back at 25 cents each.

SPECIAL NOTICE TO ADVERTISERS.

CHANGES for advertisements must be in this office by Friday noon for the following week's issue.

NEW ADVERTISEMENTS should be in the office not later than Saturday noon to insure publication the following week.

NEW YORK, AUG. 12, 1896.

CONTENTS.

INDEX OF ADVERTISERS.

COVER PAGES.

INSIDE PAGES.

An interesting communication from Mr. James Asher on improvements in thermo-electric batteries is published in this issue of the ELECTRICAL REVIEW. In spite of the fact that the most efficient batteries of this kind are said to transform less than one per cent of the heat expended into electrical energy, the problem of getting electricity direct from heat is the most fascinating one with which the electrical inventor has to deal.

TESLA ON THE NATURE OF THE ROENTGEN RAYS.

In our present issue we publish another important communication from Mr. Tesla in regard to the Roentgen rays. Mr. Tesla has worked ceaselessly, and in his articles, exclusively published in our columns, he has made most valuable contributions to the knowledge of this fascinating subject. His opinions carry the greater weight as they are supported by a mass of experimental evidence, and as his insight into many phenomena has proved to be true. What services has he not rendered to science and industry merely by his demonstrations of the action of air or gases in condensers and high-tension transformers! His present contribution is, in part, a summing up of the observations already made by him, and is particularly important in this, that it substantiates the ideas originally expressed by Professor Roentgen.

Mr. Tesla brings forward many convincing arguments to show that these rays consist of streams of matter in some primary condition, which is, to a certain extent, equivalent to saying that they are streams of ether into which the matter is dissolved by the violent impact.

There is thus opened up a wonderful possibility of transformation of matter into its primary constituents, never before contemplated or thought possible, and it is safe to say that a more absorbing subject for study and investigation could not be found in physical science.

TO STOP CUTTING PRICES.

The incandescent lamp manufacturers, after two or three years of cutting of prices, have concluded that it would be better to maintain a regular price for standard lamps hereafter, and let the customer choose his lamp for its quality and not on account of cheapness or amount of rebate. A number of manufacturers have been discussing this question for several weeks, and an agreement has been reached. This does not take the form of a trust or combination, but means, if lived up to, that prices of lamps will be steady, and that consumers will undoubtedly receive an improved article. The larger companies, like the General Electric Company and the Westinghouse Company, apparently think the agreement a good thing, and the immense number of users of the incandescent lamp hope to find that they are to be benefited as well.

DELETERIOUS EFFECTS OF X RAYS ON THE HUMAN BODY.

It seems that the wonderful effects of X rays have not all been learned. One of the newest of these takes the form of a physical effect upon the person who uses powerful X-ray apparatus for comparatively long periods at a time. Mr. H. D. Hawks, a graduate in the class of 1896, of Columbia College, has for the past few weeks been giving exhibitions in the vicinity of New York with an unusually powerful X-ray outfit. Mr. Hawks, during the afternoon and evening of each day for four days, was working around his apparatus for from two to three hours at a time. At the end of four days he was compelled to cease active work, owing to the physical effects of the X rays upon his body. The first thing Mr. Hawks noticed was a drying of the skin, to which he paid no attention, but after awhile it became so painful it was necessary to stop all operations. The hands began to swell and assumed the appearance of having a very deep sunburn. At the end of two weeks the skin all came off the hands. The knuckles were especially affected, they being the sorest part of the hand. Among other effects were the following: The growth of the finger nails was stopped and the hair on the skin that was exposed to the rays all dropped out, especially on the face and sides of the head. The hair at the temples has entirely disappeared, owing to the fact of Mr. Hawks having placed his head in close proximity to the tube to enable spectators to see the bones of the jaw. The eyes were quite bloodshot and the vision was considerably impaired. The eyelashes began to fall out and the lids to swell. The chest was also burned through the clothing, the burn resembling sunburn. Mr. Hawks's disabilities were such that he was compelled to suspend work for two weeks. He consulted physicians, who treated the case as one of parboiling.

To overcome these effects of the X rays, Mr. Hawks first tried covering his hand with vaseline and then putting a glove on, but the hand was at once burned again, the glove affording no protection whatever. The hand was finally protected by covering it with tin foil. Mr. Hawks coincides with Tesla's belief that X rays are practically minute material particles thrown off from the walls of the tube. The apparatus used was a 10-inch induction coil, manufactured by Ritchie & Son, of Brookline, Mass. The primary circuit was opened and closed by means of a rotary brake mounted on the shaft of a motor, there being 120 breaks a second. The tube used was a focusing tube, made by Emil Greiner, of New York.

Mr. Hawks has made a careful study of his case and has reached the conclusion that no other cause than his exposure to the X rays is responsible for his condition. His personal appearance certainly bears out his statement. The ELECTRICAL REVIEW will be glad to hear from any of its readers who have experienced similar effects, even in a lesser degree.

Roentgen Rays or Streams.

To the Editor of the Electrical Review:

In the original report of his epochal discoveries, Roentgen expressed his conviction that the phenomena he observed were due to certain novel disturbances in the ether. This opinion deserves to be considered the more as it was probably formed in the first enthusiasm over the revelations, when the mind of the discoverer was capable of a much deeper insight into the nature of things.

It was known since long ago that certain dark radiations, capable of penetrating opaque bodies, existed, and when the rectilinear propagation, the action on a fluorescent screen and on a sensitive film was noted, an obvious and unavoidable inference was that the new radiations were transverse vibrations, similar to those known as light. On the other hand, it was difficult to resist certain arguments in favor of the less popular theory of material particles, especially as, since the researches of Lennard, it has become very probable that material streams, resembling the cathodic, existed in free air. Furthermore, I myself have brought to notice the fact that similar material streams—which were subsequently, upon Roentgen's announcement, found capable of producing impressions on a sensitive film—were obtainable in free air, even without the employment of a vacuum bulb, simply by the use of very high potentials, suitable for imparting to the molecules of the air or other particles a sufficiently high velocity. In reality, such puffs or jets of particles are formed in the vicinity of every highly charged conductor, the potential of which is rapidly varying, and I have shown that, unless they are prevented, they are fatal to every condenser or high-potential transformer, no matter how thick the insulation. They also render practically valueless any estimate of the period of vibration of an electro-magnetic system by the usual mode of calculation or measurement in a static condition in all cases in which the potential is very high and the frequency excessive.

It is significant that, with these and other facts before him, Roentgen inclined to the conviction that the rays he discovered were longitudinal waves of ether.

After a long and careful investigation, with apparatus excellently suited for the purpose, capable of producing impressions at great distances, and after examining the results pointed out by other experimenters, I have come to the conclusion which I have already intimated in my former contributions to your esteemed journal, and which I now find courage to pronounce without hesitation, that the original hypothesis of Roentgen will be confirmed in two particulars: first, in regard to the longitudinal character of the disturbances; second, in regard to the medium concerned in their propagation. The present expression of my views is made solely for the purpose of preserving a faithful record of what, to my mind, appears to be the true interpretation of these new and important manifestations of energy.

Recent observations of some dark radiations from novel sources by Becquerel and others, and certain deductions of Helmholtz, seemingly applicable to the explanation of the peculiarities of the Roentgen rays, have given additional weight to the arguments on behalf of the theory of transverse vibrations, and accordingly this interpretation of the phenomena is held in favor. But this view is still of a purely speculative character, being, as it is at present, unsupported by any conclusive experiment. Contrarily, there is considerable experimental evidence that some matter is projected with great velocity from the bulbs, this matter being in all probability the only cause of the actions discovered by Roentgen.

There is but little doubt at present that a cathodic stream within a bulb is composed of small particles of matter, thrown off with great velocity from the electrode. The velocity probably attained is estimable, and fully accountable for the mechanical and heating effects produced by the impact against the wall or obstacle within the bulb. It is, furthermore, an accepted view that the projected lumps of matter act as inelastic bodies, similarly to ever so many small lead bullets. It can be easily shown that the velocity of the stream may be as much as 100 kilometers a second, or even more, at least in bulbs with a single electrode, in which the practicable vacua and potentials are much higher than in the ordinary bulbs with two electrodes. But, now, matter moving with such great velocity must surely penetrate great thicknesses of the obstruction in its path, if the laws of mechanical impact are at all applicable to a cathodic stream. I have presently so much familiarized myself with this view that, if I had no experimental evidence, I would not question the fact that some matter is projected through the thin wall of a vacuum tube. The exit from the latter is, however, the more likely to occur, as the lumps of matter must be shattered into still much smaller particles by the impact. From my experiments on reflection of the Roentgen rays, before reported, which, with powerful radiations, may be shown to exist under all angles of incidence, it appears that the lumps or molecules are indeed shattered into fragments or constituents so small as to make them lose entirely some physical properties possessed before the impact. Thus, the material composing the electrode, the wall of the bulb or obstruction of any kind placed within the latter, are of absolutely no consequence, except in so far as the intensity of the radiations is concerned. It also appears, as I have pointed out, that no further disintegration of the lumps is attendant upon a second impact. The matter composing the cathodic stream is, to all evidence, reduced to matter of some primary form, heretofore not known, as such velocities and such violent impacts have probably never been studied or even attained before these extraordinary manifestations were observed. Is it not possible that the very ether vortexes which, according to Lord Kelvin's ideal theory, compose the lumps, are dissolved, and that in the Roentgen phenomena we may witness a transformation of ordinary matter into ether? It is in this sense that, I think, Roentgen's first hypothesis will be confirmed. In such case there can be, of course, no question of waves other than the longitudinal assumed by him, only, in my opinion, the frequency must be very small—that of the electro-magnetic vibrating system—generally not more than a few millions a second. If such process of transformation does take place, it will be difficult, if not impossible, to determine the amount of energy represented in the radiations, and the statement that this amount is very small should be received with some caution.

As to the rays exhaustively studied by Lennard, which have proved to be the nucleus of these great realizations, I hold them to be true cathodic streams, projected through the wall of the tube. Their deflectibility by a magnet shows to my mind simply that they differ but little from those within the bulb. The lumps of matter are probably large and the velocity small as compared with that of the Roentgen rays. They should, however, be capable in a minor degree of all the actions of the latter. These actions I consider to be purely mechanical and obtainable by other means. So, for instance, I think that if a gun loaded with mercury were fired through a thin board, the projected mercury vapor would cast a shadow of an object upon a film made especially sensitive to mechanical impact, or upon a screen of material capable of being rendered fluorescent by such impact.

The following observations made by myself and others speak more or less for the existence of the streams of matter.

I—PHENOMENA OF EXHAUSTION.

On this subject I have expressed myself on another occasion. It is only necessary to once more point out that the effect observed by me should not be confounded with that noted by Spottiswoode and Crookes. I explain the latter phenomenon as follows: The first fluorescence appearing when the current is turned on, is due to some organic matter almost always introduced in the bulb in the process of manufacture. A minute layer of such matter on the wall produces invariably this first fluorescence, and the latter never takes place when the bulb has been exhausted under application of a high degree of heat or when the organic matter is otherwise destroyed. Upon the disappearance of the first fluorescence the rarefaction increases slowly, this being a necessary result of particles being projected from the electrode and fastening themselves upon the wall. These particles absorb a large portion of the residual gas. The latter can be again freed by the application of heat to the bulb or otherwise. So much of the effects observed by these investigators. In the instance observed by myself, there must be actual expulsion of matter, and for this speak following facts: (a) the exhaustion is quicker when the glass is thin; (b) when the potential is higher; (c) when the discharges are more sudden; (d) when there is no obstruction within the bulb; (e) the exhaustion takes place quickest with an aluminum or platinum electrode, the former metal giving particles moving with greatest velocity, the latter particles of greatest weight; (f) the glass wall, when softened by the heat, does not collapse, but bulges outwardly; (g) the exhaustion takes place, in some cases, even if a small perceptible hole is pierced through the glass; (h) all causes tending to impart a greater velocity to the particles hasten the process of exhaustion.

II—RELATION BETWEEN OPACITY AND DENSITY.

The important fact pointed out early by Roentgen and confirmed by subsequent research, namely, that a body is the more opaque to the rays the denser it is, can not be explained as satisfactorily under any other assumption as that of the rays being streams of matter, in which case such simple relation between opacity and density would necessarily exist. This relation is the more important in its bearing upon the nature of the rays, as it does not at all exist in light-giving vibrations, and should consequently not be found to so marked a degree and under *all conditions with vibrations*, presumably similar to and approximating in frequency the light vibrations.

III—DEFINITION OF SHADOWS ON SCREEN OR PLATE.

When taking impressions or observing shadows while varying the intensity of the radiations, but maintaining all other conditions as nearly as possible alike, it is found that the employment of more intense radiations secures little, if any, advantage, as regards the definition of the details. At first it was thought that all there was needed was to produce very powerful rays. But the experience was disappointing, for, while I succeeded in producing rays capable of impressing a plate at distances of certainly not less than 30 metres, I obtained but slightly better results. There was one advantage in using such intense rays, and this was that the plate could be further removed from the source, and consequently a better shadow was obtained. But otherwise nothing to speak of was gained. The screen in the dark box would be at times rendered so bright as to allow reading at some distance plainly, but the shadow was not more distinct for all that. In fact, often a very strong radiation gave a poorer impression than a weak one. Now, a fact which I have repeatedly observed and to which I attach great importance in this connection, is the following: When taking impressions at a small distance with a tube giving very intense rays, no shadow, unless a scarcely perceptible one, is obtained. Thus, for instance, the flesh and bones of the hand appear equally transparent. Increasing presently gradually the distance, it is found that the bones cast a shadow, while the flesh leaves no impression. The distance still increased, the shadow of the flesh appears, while that of the bones grows deeper, and in this neighborhood a place can be found at which the definition of the shadow is clearest. If the distance is still further continually increased, the detail is lost, and finally only a vague shadow is perceptible, showing apparently the outlines of the hand.

This often-noted fact disagrees entirely with any theory of transverse vibrations, but can be easily explained on the assumption of material streams. When the hand is near and the velocity of the stream of particles very great, both bone and flesh are easily penetrated, and the effect due to the difference in the retardation of the particles passing through the heterogeneous parts can not be observed. The screen can fluoresce only up to a certain limited intensity, and the film can be affected only to a certain small degree. When the distance is increased, or, what is equivalent, when the intensity of the radiation is reduced, the more resisting bones begin to throw the shadow first. Upon a further increase of the distance the flesh begins likewise to stop enough of the particles to leave a trace on the screen. But in all cases, at a certain distance, manifestly that which under the conditions of the experiment gives the greatest difference in the trajectories of the particles within *the range perceptible on the screen or film*, the clearest shadow is secured.

IV—THE RAYS ARE ALL OF ONE KIND.

The preceding explains the apparent existence of rays of different kind; that is, of different rates of vibration, as it is asserted. In my opinion, the velocity and possibly the size of the particles both are different, and this fully accounts for the discordant results obtained in regard to the transparency of various bodies to these rays. I found, for example, in many cases that aluminum was less transparent than glass, and in some instances brass appeared to be very transparent as compared with other metallic bodies. Such observations showed that it was necessary, in making the comparison, to take rigorously equal thicknesses of the bodies and

(Concluded on page 83.)

A New "Lightning Express" Electric Railway System.

A few days ago, in response to an invitation from Mr. R. Chipperfield, I went to his workshop in Great Windmill street to see a working model he had constructed of Mr. F. B. Behr's Lightning Express Railway. Mr. Behr himself was present to explain the construction of the railway, and the hopes he had of its ultimate success, and I confess that the personality of the enthusiastic inventor interested me even more than his invention.

The model departed in some respects from the plan of the railway itself, which is to be tried next year on a comparatively large scale near Brussels. The exigencies of space necessitated relatively sharper curves in the model line, and the cars had to be modified accordingly, leaving far less room in proportion for the motors. The current, too, was taken from the rail itself, whereas on the actual line it will be taken from a special conductor; and the lamps had to be lighted by the same current, so that they flashed up and down very irregularly as the contact with the rail varied or perhaps with the demand of the motor. Still, with all disadvantages the model worked; there was a good deal of sparking at the commutator, a loose wheel gave trouble, and some loose contacts gave rise to a shower of sparks; but these were difficulties due to hasty work and to the small scale on which the thing was constructed; and if there was more noise than might have been expected, that was accounted for by the fact that the line was practically laid on a sounding board, so that all sound was magnified.

I was somewhat astonished, on trying to move the cars by hand, to find how great was the resistance to motion. This I am inclined to put down chiefly to the friction of the guide rails and wheels, which in actual work will be relatively very much smaller. Mr. Behr has increased the number of these guide rails to four, and it certainly seems impossible that his cars should be derailed by anything short of a total wreck of the permanent way. I found it, however, difficult to understand why Mr. Behr insists on omitting the obvious precaution of tilting his rails at a curve. He was at some pains to prove that the strain would not come on the guide rails, but on the central rail, but he did not convince me that it was so. If I had been able to accept his reasoning, the conclusion I should have drawn would have been that most mischievous strains would be thrown on the rims and bearings of the wheels, as well as on the bolts holding the center rail in position—strains which would almost certainly lead to disaster. As, however, I feel sure that the thrust outward in going round a curve will come mainly on the guide rails, I do not anticipate any serious difficulty from this cause.

It is quite impossible to judge from the working of a model whether Mr. Behr's ambitious scheme is practicable or no, and I shall wait to see the result of the Brussels experiment. But I hope Mr. Behr will reconsider the laying of his line at the curves. Theory and experience are both against him in this matter, and though by the strength of his materials he should avoid a wreck, it is not well to subject line and car to unnecessary strains, especially as he acknowledges that the remedy is easily accomplished. Moreover, though he may by sheer force keep his *car* upright, the tendency will be to throw its contents, passengers included, against the plate-glass windows on the outer side of the car, the more so as the seats are arranged lengthways, so that half the passengers face each window. However, Mr. Behr has had many years' experience of the Lartigue single-rail system in Ireland, and he has given more than three years to the working out of his present proposal, so that any criticism of it must needs be made with a certain diffidence. I have never thought his idea quite impracticable, even when he talks of 150 miles an hour. Whether it would pay is another question, as also whether cars could be safely run at that speed at intervals of only five or ten minutes.—*London Lightning.*

LITERARY.

We acknowledge the receipt of the "Bulletin of the Electro-Therapeutical Laboratory of the University of Michigan," for July, devoted chiefly to a discussion of X-ray phenomena.

The Kansas Academy of Science, by Mr. B. B. Smyth, Topeka, Kas., has sent the ELECTRICAL REVIEW the "Transactions" of the 26th and 27th annual meetings of the Academy. The work is a very interesting one, containing much valuable information which is compactly presented and well edited by Mr. Smyth.

Along with the great mass of political literature which has been published even thus early in the presidential campaign, is the sketch of "McKinley and Hobart," by Byron Andrews. As a Washington correspondent and life-long journalist, Mr. Andrews is peculiarly well fitted to prepare biographies, and because of his forceful style the volume will become a standard addition to America's historical and political literature.

Published by F. Tennyson Neely, 114 Fifth Avenue, New York.

The new volume, "Good Advertising," just compiled and written by the advertising expert, Charles Austin Bates, is an epitome of the question of advertising relative to methods, ideas and results prepared in such a manner that any business man who advertises, even to a very limited extent, may gain practical information based on the actual experience of others. The author does not present the book as a literary effort, but as a collection of a mass of facts and information which might be in the nature of a text-book of a subject, the importance of which is so great that the acquisition of one useful hint repays an advertiser for the perusal.

The volume is published by the Holmes Publishing Company, at $5, 15-17 Beekman street, New York.

The August number of *The Home Magazine*, of Binghamton, opens with a thrillingly interesting account of the life and adventures of Captain Paul Boyton, who is appropriately called the "man-fish." Accompanying the article is a series of photographs, now published for the first time, showing Captain Boyton at various stages of his life, beginning with a view taken at the age of 10. The incident of his landing on the Irish coast, in his novel swimming suit, on his first trial trip, and how he overcame the objections of those who thought he was bent on suicide, will be found among the best things in the entertaining article. A characteristic and very readable description of the English Channel Islands, is from the pen of the late Violet Etynge Mitchell. "Drunkenness as a Disease," by Thomas E. Barry, will be read with deep interest by every student of the reform movements of the day. It presents in a vivid manner the newest temperance reform. A dozen engravings, including a portrait of Dr. Keeley, accompany the article. Among the many other attractive features of this number may be mentioned: "The Stars on the Field of 'Old Glory'," by J. F. Earhart; "A New Plan for International Waterways," by J. A. C. Wright; "The Mind Children," by J. F. Leon Mead; and two short stories by Max Nordau, the celebrated author of "Degeneration." Every dollar of profit realized from the publication of this magazine goes toward building the national home for commercial travelers at Binghamton, N. Y.

OBITUARY.

The Right Hon. Sir William Robert Grove, D. C. L., LL. D., P. C., F. R. S., died in London August 2, 1896. Sir William was born July 11, 1811, and was educated at Oxford. He was called to the bar at Lincoln's Inn. Being temporarily prevented by ill-health from following the legal profession, he began the study of electricity, and in 1839 constructed the powerful voltaic battery which bears his name. He was professor of experimental philosophy at the London Institution from 1840 to 1847, and took an active part in reforming the constitution of the Royal Society. He was president of the British Association at Nottingham in 1866, when he selected for the subject of his address, "The Continuity of Natural Phenomena."

The honor of knighthood was conferred upon him February 21, 1872. He made several important discoveries in electricity and optics. He was the author of a remarkable lecture, delivered in January, 1842, on "The Progress of Physical Science Since the Opening of the London Institution." In this he first announced the doctrine of the mutual convertibility of the various natural forces—heat, electricity, etc.—and of their being all modes of motion or forms of persistent force. He further developed the doctrine in his essay on "The Correlation of the Physical Forces."

Association of Edison Illuminating Companies.

The above association meets this week at the Oriental Hotel, Manhattan Beach, L. I., where its members are sure to be hospitably treated by the proprietor, Mr. T. F. Silleck. The officers of the association are: President, C. L. Edgar, Boston, Mass.; vice-president, Samuel Insull, Chicago, Ill.; secretary, W. S. Barstow, Brooklyn, N. Y.; treasurer, J. W. Lieb, Jr., New York, N. Y. Executive Committee: John I. Beggs, chairman, the Cincinnati Edison Electric Company, 164 West Eighth street, Cincinnati, Ohio; C. P. Gilbert, Detroit, Mich.; E. R. Weeks, Kansas City, Mo.; M. A. Beal, Rockford, Ill.; G. R. Stetson, New Bedford, Mass.; C. L. Edgar (ex-officio), Boston, Mass. The meeting began August 11 and will continue through the 12th and 13th, the latter day being devoted to a trip to Schenectady to visit the extensive works of the General Electric Company.

Secretary Barstow announces that the meetings of the convention promise to be especially interesting. The Executive Committee have had many important meetings during the past year, and will submit suggestions. Besides the reports of the various committees, there will be papers on the selection of alternating-current apparatus for central lighting stations, and the experience of large Edison stations in this direction. The recent developments in the new underground systems and the use of cables as auxiliaries thereto will be exhaustively treated. The actual results obtained from the operation of large storage batteries in New York and Boston will be another subject of importance, as will also the English or Wright-Demand system of charging for current. Besides the topics mentioned above, there will be several other papers which can not fail to interest all Edison licensees.

As, in accordance with a decision of the Executive Committee several years ago, the papers will be published only in the minutes of the association, the secretary urges the attendance of every representative possible, in order that a full discussion may be obtained.

In accordance with the custom of previous conventions, the business sessions will be relieved by entertainments, and provision will be made for the ladies during the time of the meetings. The third day will be devoted entirely to entertainments by the acceptance of the invitation from the General Electric Company to accompany them on a special train to Schenectady and visit their works. Special arrangements have been made on this trip for the ladies of the convention, so that it is expected all will participate. A detail programme of the convention will be furnished the delegates on their arrival at the hotels. Any members desiring to visit the stations of the Edison Electric Illuminating Company of Brooklyn were invited to do so, informally, on Monday, August 10, as the programme of the convention did not admit of a later formal visit.

NATIONAL ELECTRIC LIGHT ASSOCIATION.

PRESIDENT'S INTERIM REPORT.

When elected president of your association, I fully realized that much useful work might be accomplished during the interval between conventions, and have earnestly endeavored since our last annual meeting to initiate and, with the assistance of our secretary, to conclude certain matters which I am hopeful will be approved of by our members, and upon which I now have the honor to report as follows:

Relations between Manufacturing and Central Station Companies—At our last convention the Committee on Relations between Manufacturing and Central Station Companies was discharged, and the Executive Committee authorized to take such action as might, from time to time, be found necessary, in an endeavor to protect its active members from having their investments in central station companies destroyed, or seriously impaired, as a result of ruinous competition, directed or fostered by the manufacturing companies. At an early period of my administration such a case arose, in a western town, as justified prompt and energetic action on the part of your association. After consultation with the members of the Executive Committee, I placed the views of our association as to this particular case, and as to unwise and unwarranted competition in general, before the executive officers of the following manufacturing companies:

Ball Electric Light Company, Brush Electric Company, Fort Wayne Electric Corporation, General Electric Company, Royal Electric Company, of Peoria, Siemens & Halske Electric Company, Stanley Electric Manufacturing Company, Western Electric Company, Westinghouse Electric and Manufacturing Company.

The details of our negotiations, by correspondence and in some cases by personal interview, are too voluminous to here set forth, but it is with much satisfaction that I am able to report that each of these companies, with the exception of the Ball Electric Light Company, has given favorable consideration to the representations made on behalf of your association, and I have received, in writing, such satisfactory assurances regarding not only the particular case in question, but also as to their future general policy, that I am hopeful of good results. Should, however, any active member have reasonable cause for complaint, he should forward full corroborative details to our secretary, and the association will take prompt and energetic measures, if the circumstances warrant such action.

Municipal Lighting Statistics—Being aware that no recent and reliable statistics of the cost of arc lighting in the cities and towns were available for use by members of the association, I some time since instituted correspondence with the municipal authorities of each city and town in the United States, with the object of securing from official sources and by official authority reliable information from each place as to (1) the number of arc lamps, (2) their candle-power, (3) the hours of burning, (4) the cost per lamp per night. Accompanying this report you will receive, in pamphlet form, a preliminary bulletin, containing such information from over 400 cities and towns, which list covers a very large majority of the principal installations. A supplementary list, containing similar information in regard to places now omitted, is in process of compilation, and will be issued to members at an early date. It frequently happens that when a contract is to be renewed, local papers publish very misleading figures concerning prices paid for arc lights in other municipalities, and as these statistics are of the months of June and July, 1896, they are reliable and up to date.

Laws Affecting Electrical Companies—We have been in correspondence with the Secretaries of State for each of the States in the Union, with a view to making arrangements to have regularly forwarded to the association copies of all bills introduced in any State that may deal with the rights of electrical companies. I am much pleased to be able to report that a large majority of the States have acceded to our request, and several have already forwarded copies of all bills passed during the past session of their legislature, while others have promised to forward any that may be introduced during future sessions. These will all be filed in the secretary's office for the sole use and advantage of the members of the association.

Revision of Constitution—As the only printed copies of the constitution and by-laws of the association did not contain recent additions and amendments, revised copies have been published, and may be obtained from the secretary.

Report of Proceedings of Nineteenth Convention—The report of the recent convention, held in this city, is now in the printer's hands, and will be delivered to members not later than September 1, next. There has been some unavoidable delay, caused by speakers at the convention failing to revise the stenographic copy of their remarks, but, so far as my memory serves, it will be issued much in advance of previous reports.

Improved Office Facilities—The office of the association being too small to be of service to our members visiting New York, the chairman of the Finance Committee made arrangements to rent the adjoining office, with the special object of providing a room for the use of our out-of-town members. The office is centrally located in the downtown business district. Members can use this room for meetings, appointments, etc., and their letters and telegrams can be addressed here. As the records of the association are increasing in number, two new bookcases have been provided, and already contain many books of reference.

In conclusion, I wish to bear testimony to the zeal of our secretary, without whose enthusiastic co-operation it would have been impossible to have accomplished so much in so short a time. I also have to request that members will aid me, by suggesting any action that may promote the welfare and add to the usefulness of the association.

Yours faithfully,

FREDERIC NICHOLLS,
President.

New York, August 1.

The Growth of the New York Telephone System.

No community in the world appreciates more keenly than this one the appliances and services placed at man's disposal by modern science, especially if they can be had at a moderate price. The introduction by the Metropolitan Telephone and Telegraph Company, whose business in New York city has been taken over by the New York Telephone Company, of a scale of rates for telephone service based on the actual use of the service by the subscriber meant to a large number of actual and possible users of the telephone a substantial reduction in the cost of telephone service. Consequently the past year has witnessed an increase of more than 2,500 telephone stations connected to the New York system. Tastes and requirements regarding telephoning differ as much as in anything else. One man wants to telephone all day long, another two or three times a day, while another practically does not call up at all, but wants the connection so that others may be able to call him. Therefore, a rate of $90 a year and upward, according to use, appeals to a vastly wider circle than a flat rate of $240 without regard to use. Especially as neither the quality of the equipment nor the efficiency of the service has been in the least diminished to provide for the low rates. The $90 subscriber gets his long-distance instruments, his metallic circuit line and rapid service, just the same as the $240 man. Liberty, equality and efficiency is the motto of the telephone company; liberty to kick if anything goes wrong, equality in equipment,and efficiency of service for all. The only difference is that the large user pays a higher toll.

The new rates have proved so popular in the upper part of the city among private residences, uptown business houses and retail stores, that the New York company has installed a detachment of its contract department staff in an office at 113 West Thirty-eighth street, close to Broadway. Uptown customers of the company will henceforward be able to transact all their business regarding telephone service at the new office, saving the journey down to headquarters at Cortlandt street.

A large firm of pump and engine builders in Indianapolis has applied for a receiver, giving as the cause of the assignment the free silver agitation, which, they say, has destroyed their business.

TRUE RESISTANCE.

BY ROLLO APPLEYARD, IN THE LONDON "ELECTRICIAN."

There is one view of the problem of the electric arc which may be worth the attention of those who are trying to interpret experimental work of recent publication. We have been given a concise statement of the conditions which engender the so-called "negative resistance." We have been told that it occurs in arcs formed between solid carbons, simultaneously with back electro-motive force. The first analytical step is to consider the correctness or otherwise of predicating "resistance," under any circumstances, of an arc; leaving out of the question, for the time being, the lesser issue, as to whether the algebraic sign of the assumed resistance is positive or negative.

That which we are in the habit of calling "resistance," and generally represent by R in electrical formulæ, is a conception derived from our experience of homogeneous metallic conductors; *i. e.*, it is a quality of a particular class of conductors. Its most pronounced characteristics are its independence of the current flowing, its independence of the potential of the conductors, and its positive sign. While, however, this conception of this physical quality is primarily derived from our experience of homogeneous metallic conductors, it may probably be rightly extended to some other substances—*e. g.*, to electrolytes, and perhaps dielectrics—on the ground that these obey the same law in the conduction of currents of electricity as metallic conductors; viz., that the current is proportional to the electro-motive force applied, and is in the same direction as the fall of potential. But when conducting mechanisms such as gases, conductors by convection, or arcs are concerned, we are not justified in predicating this quality of resistance of them, without such experimental grounds as justify us in the case of electrolytes.

And when, by assigning the quality of resistance to a conductor, we find that this involves the resistance having a negative sign, we should be prudent to retrace our steps and our language.

No one denies that the arc has a certain quality in virtue of which energy is transformed in it by the passage of a current. We may, of course, represent this quality by R, or by any symbol we please. Without proof we are not justified in speaking of it in connection with the arc, in the same sense as that in which we speak of the defined "resistance" of a homogeneous metallic conductor.

The truth is, we have no rigorous definition of resistance except as an attribute of homogeneous metallic conductors; the "arc" controversy seems to have arisen from the neglect of this fact. The term has been decoyed into the interpretation of results quite foreign to it. Even with the positive sign, "true resistance" has no proven right in equations concerning the arc.

ON HYPERPHOSPHORESCENCE.

BY SILVANUS P. THOMPSON, D. S. C., F.R.S., IN THE "PHILOSOPHICAL MAGAZINE."

The recent researches of H. Becquerel† on the emission by compounds of uranium and by metallic uranium of invisible radiations which very closely resemble those discovered by Wiedemann‡ and Roentgen,§ and which yet unquestionably consist of transverse vibrations, are of so great importance that any experiments upon the same line, however incomplete, are of interest to physicists.

In January last the writer and his assistant, Mr. Miles Walker, were repeating Roentgen's now familiar experiments on the production of photographic shadows by the emanations from Crookes tubes, and were casting about for means to shorten the long exposures then necessary, when the idea occurred to them which has independently suggested itself to many other experimenters—namely, that of employing fluorescent substances in contact with the photographic film to hasten the photographic action by the emission of rays of a visible sort when stimulated by the X rays. Accordingly, having prepared sheets of paper or of aluminum covered with fluorescent material, they tried the effect of inserting them in some cases below the glass plate, in other cases above the glass plate, but with the fluorescent surface next the film, and in yet other cases above the plate, but with the fluorescent surface outside. The materials so tried were sulphide of calcium, finely powdered fluor-spar, sulphide of zinc (natural blende), sulphide of zinc (artificial), fluoride of uranium and ammonium, and sundry platino-cyanides.

When sheets of paper or aluminum covered with these were placed face down upon the sensitive film, so that the X rays were compelled to pass first through them, some results were obtained tending to show that the method might have some advantages, but the resulting negatives were always patchy and irregular. The most striking effect, however, was quite unexpected. Care had been taken to keep these prepared sheets of fluorescent material in the dark for a sufficiently long time for all visible phosphorescence or persistent fluorescence to disappear. This, in the case of the sulphide of calcium, required many hours. The powdered fluor was also heated beforehand. Nevertheless, though no visible phosphorescence was present, the sensitive films were fogged by rays emitted from these materials. Fluor-spar and the platino-cyanides did not produce any noticeable fogging, however. Even after being kept six weeks in darkness, the sulphide of calcium is very active in the emission of rays that will affect a photographic plate.

While these experiments were in progress other experiments were begun, to ascertain if from any other sources, such as sunlight or the light of the arc lamp, any rays could be obtained having, like the X rays, the power of penetrating opaque bodies. From the arc lamp, with an exposure of about two hours, shadows of pieces of metal were obtained on a photographic plate through a piece of pine wood several millimetres thick; but aluminium was found to be totally opaque to everything radiated from the arc and to sunlight.

While the experiments on fogging were still in hand there was published the observation of M. Henry on the effect of sulphide of zinc in apparently augmenting the transparency of aluminum to X rays—an observation which had an obvious bearing on that which was under investigation. A number of small portions of the fluorescent substances with which we were experimenting were then placed upon the front of a sheet of aluminum about 0.5 millimetres thick, behind which was a gelatino-bromide plate (a Cadett's "lightning" plate), and these were left for several days upon the sill of a window facing south to receive so much sunlight (several hours, as it happened) as penetrates in February into a back street in the heart of London. On developing the plate, it was found that behind those spots where portions of uranium nitrate and uranium ammonium fluoride had been placed, photographic action had taken place through the aluminum sheet. No very distinct effect had been produced by the other substances. On communicating these observations to Sir G. G. Stokes, he drew the writer's attention to the similar observations of M. Becquerel with respect to uranium salts, observations which have since been so remarkably extended. While agreeing with the Roentgen rays in the property of penetrating aluminum, zinc, and other opaque materials, and in exercising photographic actions, the Becquerel rays differ in the circumstance that they can be refracted and polarized. Whatever the Roentgen rays may eventually prove to be, the Becquerel rays consist of transverse waves of an exceedingly high ultra-violet order.

The circumstance that the strongest fluorescent effects are found in the compounds of two metals having such heavy atomic weights as platinum and uranium, when correlated with the other circumstance that the absorbing power towards X rays is greatest in elements of the greatest atomic weights, naturally suggests a new application of the law of reciprocity between emission and absorption. If that law can hold good in the phenomena of the Roentgen rays, or of the closely related Becquerel rays, one would argue that the best substances to employ as emitters of such radiations would be those substances which absorb them most freely. Now, the property of emitting Roentgen rays has been observed in many substances, but always under the stimulation of the cathodic discharge. In Roentgen's original research glass was the radiator. Porter and Jackson independently found platinum foil to be superior. Roiti has found porcelain and mica also to serve. The writer has observed Roentgen rays to be emitted from the following substances exposed to cathode discharges: calc-spar, apatite, rubies, sapphires, diamonds, uranium glass, scheelite, tourmaline, a phosphorescent enamel containing 60 per cent of sulphide of calcium, sulphide of zinc (hexagonal blende), zinc, aluminum, copper, iron, magnesium and platinum. Of the metals in the above list, iron and platinum appeared to work better than copper, aluminum or magnesium. The low melting points of the last two render them unsuitable. Metallic uranium would have been tried had it been possible* to obtain a specimen, but all inquiries in London proved fruitless. Of the other substances named, the phosphorescent materials seemed to have some advantages over ordinary glass, but they are not so convenient to manage as the metals. Apatite was tried because, consisting as it does chiefly of phosphate of lime, it was thought that the X ray emitted from its surface could be more certainly absorbed by bone than are the X rays emitted from denser materials, such as platinum.

At an early stage of these investigations the use of a fluorescent screen revealed the fact that the relative transparency of flesh and bone differed with different materials used as emitters, and depended also upon the degree of exhaustion. The necessary inference that the X rays are not all of one kind, but are heterogeneous, was announced by the writer about the same time† that the same conclusion was drawn by MM. Benoit‡ and Hurmuzescu from other causes. To the rays emitted from apatite, bone was indeed found to be more opaque than to those emitted from platinum. But apatite, when subjected to the cathode discharge, continues to give out gases which after a very few seconds spoil the vacuum; and the tube containing apatite as an anti-cathode could not, consequently, be used except attached to the pump. Glass was found to be more transparent to X rays emitted from platinum than to X rays emitted in the same tube from glass.

The extraordinary property exhibited by the uranium compounds of emitting a persistent invisible radiation that will pass through aluminum and produce photographic action would suggest that these rays are identical with Roentgen's, were it not that Becquerel's success in reflecting, refracting and polarizing them proves that they are more akin to ultra-violet light. The latter does not indeed penetrate aluminum, but it has long been known that ultra-violet rays penetrate films of silver, which, though thin, are thick enough to reflect all visible kinds of light. It would seem to be proved, then, that Becquerel's rays differ from the known ultra-violet in degree rather than in kind, being rays of higher frequency and shorter wave length. That their properties are intermediate between those of ultra-violet and of the Roentgen rays furnishes a strong presumption that the latter also differ only in degree, and are an extreme species of ultra-violet light. It should not be forgotten that so far back as 1857 M. Niépce de Saint Victor observed many cases in which an object, an engraving on paper or a figured piece of porcelain or marble, immediately after exposure to sunlight, was found capable of giving a photographic impression to a sheet of paper prepared with chloride of silver, with which it was placed in contact. He even used, after exposure to light, cardboard imbibed with salts of uranium or with tartaric acid, and found such to be capable of emitting rays that were photographically active. There was no attempt made, however, to investigate the possibility of transmitting these invisible radiations through opaque bodies.

The phenomenon of persistent emission of these invisible rays by the uranium compounds long after any electrical or luminous stimulus has ceased to be applied would seem, therefore, to bear the same relation to the transient emission of them in the Crookes tube as the persistent emission of visible light by phosphorescent bodies does to the transient emission of light by fluorescent bodies, hence the writer ventures to give to the new phenomenon thus independently observed by M. Becquerel and by himself the name of hyperphosphorescence. A hyper-phosphorescent body is one which, after due stimulus, exhibits a persistent emission of invisible rays not included in the hitherto recognized spectrum.

† Comptes Rendus, CXXII, pp. 559, 790, etc.

‡ Zeitschrift fur Elektrochemie, II, p. 159 (August, 1895).

§ Sitzungsberichte der Wurzburger Physik-medic Gesellschaft, 1895.

* [While these lines have been going through the press, a specimen of metallic uranium has been given me by Mr. C. Vautin. It emits X rays freely under the cathode discharge.—S. P. T.]

† Comptes Rendus, CXXII, p. 807.

‡ Ibid., CXXII, p. 779.

Assignment of H. E. & C. Baxter.

The electrical supply house of H. E. & C. Baxter, Brooklyn, N. Y., on August 3 made an assignment in the interest of their creditors, without preference. They expect to be able to give a showing that will be satisfactory to their creditors, a meeting of whom will be called as soon as an account of stock is taken and the statement showing the condition of the business is completed.

Messrs. H. E. & C. Baxter are well known to the electrical manufacturing field as gentlemen of integrity and industry, and their many friends hope that they will soon recover from their temporary embarrassment.

MANUFACTURING NOTES.

Two suits for $20,000 each have been filed by Ed Morris and wife against the Westinghouse Electric and Manufacturing Company. The son of the plaintiffs, Thomas Morris, was killed by the explosion of an emery wheel, July 22, 1895, at the works of the defendant company.

Japan's Diet voted $45,000,000 for the construction of railroads, telegraphs and cables at its last session, and $97,000,000 for the construction and purchase of war materials and ships. Since January, 1895, $600,000,000 has been invested by Japanese in banks, railroads and other companies.

POLICE AND FIRE TELEGRAPH SUPERINTENDENTS.

A NATIONAL ASSOCIATION TO BE FORMED ON SEPTEMBER 15—SUPT. F. C. MASON, OF BROOKLYN, ISSUES THE CALL.

Away back in the dim mists of antiquity, even at a more remote date than the retentive memory of the oldest inhabitant, some one suggested that in his judgment the superintendents of police and fire telegraph bureaus of the United States and Canada should meet once a year for consultation, enjoy a dinner and conduct themselves generally as other officials do whose duties bring them into close personal relation. The rash individual who broached the subject was at first looked upon with suspicion by his fellow workers, was then tabooed and eventually passed into a nameless grave. It remained, however, for Mr. F. C. Mason, superintendent of the police telegraph system of Brooklyn, N. Y., to start the ball rolling in the right direction with sufficient momentum to reach those interested. He has placed the matter before his brother officials in such a concise and business-like form as to immediately fire them with a desire to make this association the most notable one of its kind in the world.

Letters were sent to the telegraph superintendents of the leading cities requesting co-operation and suggestions. Many replies have been received, all in favor of forming the association. The first meeting has been called for Brooklyn, N. Y., on September 15, and arrangements are being perfected to give those present a most enjoyable time, including a sail on the ocean, fish dinner at Pleasure Bay, and an evening at Manhattan Beach.

Officers for the first year will be elected at this meeting, members elected and an organization perfected. The following gentlemen have, up to the present time, signified their intention of assisting in the work of the new association:

Pittsburgh, Pa., M. W. Mead, superintendent, Bureau of Electricity.

Chicago, Ill., John P. Barrett, superintendent, Bureau of Electricity.

Boston, Mass., Brown Flanders, inspector of wires.

Baltimore, Md., L. Lemon, superintendent.

Washington, D. C., H. R. Miles, superintendent, Tel. and Tel. Service.

Richmond, Va., W. H. Thompson, superintendent, F. and P. Teleg.

Cincinnati, Ohio, J. A. Archibald, fire marshal.

Buffalo, N. Y., Henry Smith, chief operator.

Albany, N. Y., M. E. Higgins, chief.

Troy, N. Y., Jas. Knibbs, superintendent, F. A.

Rochester, N. Y., C. R. Barnes, superintendent.

Macon, Ga., C. H. Humphreys, superintendent, F. and P. Teleg.

Denver, Colo., Julius Pearse, chief.

San Francisco, Cal., Walter Hewitt, superintendent, F. A.

New Orleans, La., Geo. T. Butler, superintendent, F. A.

Omaha, Neb., Geo. A. Coutler, superintendent.

Atlanta, Ga., W. R. Joyner, chief, Fire.

Atlanta, Ga., A. B. Connolly, chief, Police.

St. Paul, Minn., Thos. Carey, superintendent.

Minneapolis, Minn., Z. T. Morrison, F. and P. Tel.

Louisville, Ky., Edward Hughes, chief, F. D.

Savannah, Ga., W. D. Claiborne, superintendent, Police Telg.

Jacksonville, Fla., T. W. Hancy, chief, F. D.

Tampa, Fla., J. F. Ahlers.

Indianapolis, Ind., J. W. Webster, chief, F. D.

Milwaukee, Wis., Jas. Foley, chief, F. D.

St. Louis, Mo., S. J. Benedict, superintendent.

New Haven, Ct., W. C. Smith, superintendent, Police.

Providence, R. I., C. G. Cloudman, superintendent, Fire.

Providence, R. I., N. M. Russell, superintendent, Police.

Portland, Me., L. L. Cummings, city electrician.

Brooklyn, N. Y., F. C. Mason, superintendent, Police Telg.

Toronto, Ont., R. J. McGowan, secretary, F. D.

Montreal, Canada, Z. Benoit, chief, F. D.

Detroit, Mich., W. J. Gardiner, superintendent, Fire Alarm.

Dayton, Ohio, D. C. Larkin, chief, Fire Department.

Cleveland, Ohio, R. L. Palmer, Director of Fire.

Toledo, Ohio, C. F. Wall, chief.

Jersey City, N. J., W. H. Foley, superintendent, Police Telg.

Jersey City, N. J., Jno. Speicher, superintendent, Fire Telg.

Newark, N. J., Adam Bosch, superintendent, F. A.

Atlantic City, N. J., C. W. Brubaker, superintendent, F. and P. Tel.

Charleston, S. C., O. G. Margenhoff, chief, F. D.

Charleston, S. C., W. H. Easterlin, superintendent, Police Tel.

Syracuse, N. Y., Thos. Tyrrell, superintendent, Fire Alarm.

Syracuse, N. Y., M. J. Myers, superintendent, Police Alarm.

Utica, N. Y., J. J. Garthside, chief.

Columbus, Ohio, W. H. Murphy, superintendent, City Telg.

Allegheny, Pa., J. R. Murphy, Department Public Safety.

Elmira, N. Y., W. Y. Ellett, Fire Tel.

New York, N. Y., M. R. Brennan, Police Tel.

Corning, N. Y., F. P. Foster, F. A.

Trenton, N. J., C. E. Drake, P. and F.

Springfield, Mass., S. L. Wheeler, F. and P.

Wilmington, Del., J. W. Aydon, F. and P.

Bridgeport, Ct., W. A. Barnes, F. and A.

Among the many letters favoring the idea, Mr. Mason has received the following, and it is safe to predict that the association will be successfully launched:

I am in receipt of your communication of June 15, in reference to organizing an association of Municipal Police and Fire Telegraph Superintendents. Now, that is the proper thing, and New York the proper place to open the ball.

I am in favor of having the permanent office in New York during the bathing season, but think it ought to be moved South in the Winter time. October is a little bit too late in the season to have your first meeting. Can't you have it in August or September?

In any event I am with you in the good cause, and I know of no man in America who is better qualified to organize a good, all-around entertainment.

Yours sincerely,
(Signed) J. P. BARRETT,
Superintendent of City Telegraph.

Chicago, Ill., June 22.

I am in receipt of your letter in reference to the formation of a National Association of Municipal Police and Fire Telegraph Superintendents of the United States.

I think it is a good move and I most heartily concur with your plan, and will promise you that I will do all in my power to make the association a success.

Very respectfully yours,
(Signed) W. D. CLAIBORNE,
Superintendent Fire and Police Telegraph.

Savannah, Ga., June 24.

Your communication of the 15th inst., duly received. Such an association of Municipal Telegraph Superintendents ought to be of considerable benefit to its members.

I heartily indorse your proposal and will do what I can to further its interests.

Very truly yours,
(Signed) WILLIAM R. HEWITT,
Superintendent Fire Alarm.

San Francisco, Cal., June 24.

Yours, June 23, at hand, and contents noted, and in reply to same would say that I consider the idea a very good one. I think anything that brings individuals of any one craft together will be to the mutual interest of all.

Please advise me of any further move that may be made in the matter, and oblige.

Yours truly,
(Signed) THOMAS CAREY,
Superintendent Fire Alarm.

St. Paul, Minn., June 25.

I beg to acknowledge receipt of yours of 15th inst., re to forming a national association of Fire and Police Superintendents.

In my opinion such an association would be of great value to municipalities throughout the country, as well as to the members individually. You can depend upon my hearty co-operation.

Yours very truly,
(Signed) L. LEMON,
Superintendent.

Baltimore, June 19.

This week a committee, consisting Messrs. Mason, of Brooklyn; Brennan, of New York, and Foley, of Jersey City, will meet and arrange the plans for preliminary organization and a programme for the convention.

ELECTRIC RAILWAY NOTES.

The Hardie air motor was last week tested several times, with apparent success, on the tracks of the 125th street cable road in New York city.

The New York Stock Exchange has listed \$5,500,000 5 per cent 30-year consolidated mortgage bonds of the Milwaukee Electric Railway and Light Company.

The following statement of gross earnings of the Brooklyn Rapid Transit Company was issued last week.

	Gross earnings month of July. 1894.	1895.	1896.
Brooklyn Heights R. R. Co........	\$443,556.91	\$407,723.48	\$431,212.43
Brooklyn, Queens Co. & Sub. R. R. Co..............	53,824.05	64,879.97	68,804.00
Total...........	\$497,380.96	\$472,603.45	\$500,016.43

The increase of receipts over 1894, as will be seen, is less than \$3,000, a much poorer showing than it was expected would be made.

The Mayor of Milwaukee has signed the franchise of the Milwaukee & Waukesha Electric Railway. President McDonald says: "We have been ready for some time, but shall now go ahead at once. We shall have the system in operation within 12 months. The line is expected to cost about \$2,000,000." New York interests are said to be in this company and that the bonds are likely to be placed in the East. The road to be built will have some bearing upon the Milwaukee Street Railway line, in which the North American company has been interested.

KIND WORDS.

PRAISE FOR THE "REVIEW."

To the Editor of Electrical Review:

We wish to take this opportunity of saying that we have nothing but praise for your paper.

THE JEFFREY MANUFACTURING COMPANY, R. H. JEFFREY.

August 5, 1896.

Edison Electric Illuminating Company of Boston declared the regular quarterly dividend of 1¾ per cent, payable August 1. Books closed July 21 and reopened August 3.

ROENTGEN RAYS OR STREAMS.

(Concluded from page 79.)

place them as closely together as possible. They also showed the fallacy of comparing results obtained with different bulbs.

V—ACTION ON THE FILMS.

Many experiments with films of different thicknesses show that decidedly more detail is obtainable with a thick film than with a thin one. This appears to me to be a further evidence in support of the above views, as the result can be easily explained when considering the preceding remarks.

VI—THE BEHAVIOR OF VARIOUS BODIES IN REFLECTING THE RAYS,

on which I have previously dwelt, will, if verified by other experimenters, leave no room for a doubt that the radiations are streams of some matter, or possibly of ether, as before observed.

VII—THE ENTIRE ABSENCE OF REFRACTION

and other features possessed by the light waves has, since Roentgen's announcement, not yet been satisfactorily explained. A trace at least of such an effect would be found if the rays were transverse vibrations.

VIII—THE DISCHARGE OF CONDUCTORS

by the rays shows, in so far as I have been able to follow the researches of others, that the electrical charge is taken off by the bodily carriers. It is also found that the opacity plays an important part, and the observations are mostly in accord with the above views.

IX—THE SOURCE OF THE RAYS

is, I find, always the place of the first impact of the cathodic stream, a second impact producing little or no rays. This fact would be difficult to account for unless streams of matter are assumed to exist.

X—SHADOWS IN SPACE OUTSIDE OF THE BULB.

An almost crucial test of the existence of material streams is afforded by the formation of shadows in space at a distance from the bulb, to which I have called attention quite recently. I will presently refer to my preceding communication on this subject, and will only point out that such shadows could not be formed under the conditions described, except by streams of matter.

XI—ALL BODIES ARE TRANSPARENT TO VERY STRONG RAYS.

Experiments establish this fact beyond any doubt. With very intense radiations, I obtain, easily, impressions through what may be considered a great thickness of any metal. It is impossible to explain this on any theory of transverse vibrations. We can show how one or other body might allow the rays to pass through, but such explanations are not applicable to *all* bodies without exception. On the contrary, assuming material streams, such a result is unavoidable.

A great many other observations and facts might be added to the above, as further evidence in support of the above views. I have noted certain peculiarities of bodies obstructing a cathodic stream within the bulb. I have observed that the same rays are produced at all degrees of exhaustion and using bodies of vastly different physical properties, and have found a number of features in regard to the pressure, the vacuum, the residual gas, the material of the electrode, etc., all of which observations are more or less in accord with what I have stated before. I hope, however, that there is enough in the present lines to enlist the attention of others.

NIKOLA TESLA.

New York, August 11, 1896.

ILLUSTRATED
ELECTRICAL REVIEW
A Journal of Scientific and Electrical Progress

Vol. XXIX.—No. 23.
Copyright, 1896, by Electrical Review Pub. Co.

NEW YORK, WEDNESDAY, DECEMBER 2, 1896.

TEN CENTS A COPY.
THREE DOLLARS A YEAR.

X-RAY APPARATUS.

BRANCHES:
Kansas City, Mo., Gate City Electric Co.
St. Louis, Southern Electrical Supply Co.
New Orleans, 404 Carondelet St.
Buffalo, 742 Guaranty Building.

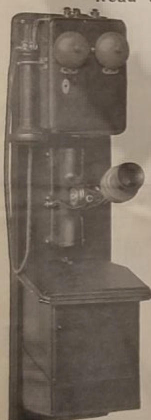
Improved Crookes Tubes.
Induction Coils, all Sizes and Prices.
FLUROSCOPES.
BATTERIES.

Complete outfits for Schools, Colleges and Laboratories. Send for new Illustrated Catalogue No. 49.

Central Electric Company,
WHOLESALE SUPPLIES,
CHICAGO.

BUY TELEPHONES THAT

are not cheaply and poorly constructed. Buy instruments that are known to stand the test of time and service. We manufacture in our factory all parts of our apparatus, and own or control every patent under which it is made.
Read the letter from the U. S. Engineer's Office:



No. 3.

MONTGOMERY MEIGS, U. S. Civil Engineer, In Local Charge.

Reports of LIEUT. COL. W. R. KING, Corps of Engineers, U. S. A. Office: ROCK ISLAND, ILL.

U. S. ENGINEER OFFICE.

KEOKUK, IOWA, March 24, 1896.

The Conn. Telephone & Electric Co.
Meriden, Conn.

Gentlemen:-

I have received and tested both the instruments you sent to me on trial, and have selected the instrument marked #3, for our use.

The telephones seem to leave little to be desired in workmanship or efficiency. I had them connected up, eight telephones in a series with seven and one-half miles of wire in the line and both of the instruments work perfectly, ring all the bells loudly, and seem to be first rate. The larger instrument, with the bracket for a mouth-piece, however, seemed to give slightly better results than the other.

I am surprised and delighted with the instruments. Please send me the rest of the telephones to complete our line.

I enclose abstract of bids received.

Very respectfully,
M. Meigs
U. S. C. E.

No. 20.

The No. 3, as shown above, is a most popular instrument. It is fitted with our regu'ar 10,000-ohm Magneto Gravity Switch, Long-Distance Transmitter and Arm, Standard Receiver, and single-cell Battery Box.

The woodwork on all of our Magneto 'Phones is of best selected stock and is highly polished. There are several thousand of this style of instruments in use for exchange work, giving satisfaction. Dimensions, 29½ inches high, 7½ inches wide. Furnished in Antique Quartered Oak or Black Walnut, and wired for series or multiple work.

The No. 20 instrument for intercommunicating systems is high class, but low in price. Two to ten or more of these instruments, with one to three cells of battery at each station, can be run in series on one line.

A system of this 'Phone in series, or on a single line, is very inexpensive to install, and is as reliable as an expensive magneto call system, at one-third the cost.

For Prices and Discounts, and new Catalogue of all Telephone Apparatus, write

CONNECTICUT TELEPHONE & ELECTRIC CO.,

CHICAGO OFFICE, 195 La Salle St. **MERIDEN, CONN., U. S. A.**

MORRIN "CLIMAX."

This boiler has been on the market for several years past, and is in use in many of the largest power stations in the United States.

IT IS BUILT IN UNITS OF FROM 50 to 1,000 HORSE-POWER.

MANUFACTURED BY

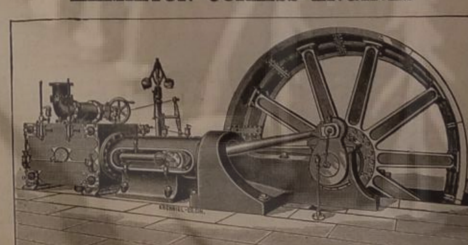
THE CLONBROCK STEAM BOILER COMPANY,

BROOKLYN, N. Y.

SEND FOR NEW CATALOGUE.

THE HOOVEN, OWENS & RENTSCHLER CO., HAMILTON, OHIO.

HAMILTON CORLISS ENGINES



FOR ELECTRIC RAILWAY AND ELECTRIC LIGHT OF ALL SIZES AND FOR ALL PURPOSES.

IRON CASTINGS.

High-Grade Castings for Dynamos, Motors and Electrical Machinery, also Fine Soft Castings for Telephones, Arc Lamps, Electric Bells, etc., etc.

(MAIN FOUNDRY-ROOM, 530 BY 110 FEET.)

THE SESSIONS FOUNDRY CO., BRISTOL, CONN.

The UPTON Arc Lamp

FOR ALL CIRCUITS.

SIMPLEST IN MECHANISM.

CHEAPEST to BUY, USE and MAINTAIN.

ORIGINAL MANUFACTURERS OF THE SIMPLEX, WARD AND KNIGHT LAMPS.

Write for Catalogue A 31.

New York Agent, F. L. Haviland, 253 Broadway.

Factory and Main Office, Peabody, Mass.

STANDARD THERMOMETER & ELECTRIC COMPANY.

GORDON PRIMARY BATTERY

Excels in

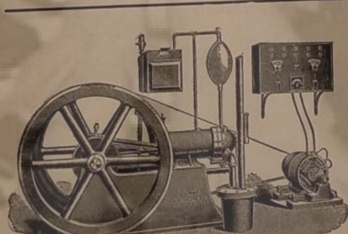
1. *LONG LIFE.*
2. *EFFICIENCY.*
3. *ECONOMY.*
4. *ADAPTABILITY.*
5. *IT IS ABSOLUTELY NON-FREEZING.*
6. *LABOR SAVING.*
7. *FREE FROM LOCAL ACTION.*
8. *FREEDOM FROM GASES AND ODORS*
9. *SUPERIOR GENERATION OF ENERGY.*

These Batteries are in use by the most prominent Telephone, Fire Alarm and Railway Companies of America. Send for descriptive Circular and Price-List. We guarantee all our Cells.

MANUFACTURED BY

THE GORDON-BURNHAM BATTERY CO.,

82 West Broadway, New York.



AT full load we guarantee voltage fluctuation not exceeding two volts, and gas consumption not exceeding 50 cubic feet per kilowatt hour, equal to from 16 to 25 full powered 16 candle-power lamps, according to wattage of lamp used.

Climax Gas Engine Co.,

Manufacturers of Gas Engines for Electric Light and All Other Power Purposes,

31 Fulton St., BROOKLYN.

The only Gas Engine exhibited with Ammeter, Voltmeter and Gas meter in full view, which enables intending purchasers to test the truth of our statements before purchasing engines, instead of having to take statements and engines on faith.

ENCLOSED ARC LAMPS

FOR CONSTANT-POTENTIAL CIRCUITS.

SIMPLE!

DURABLE!!

ECONOMICAL!!!

Burns 100 to 150 hours with 12-inch Carbon.

DIEHL MANUFACTURING Co.,

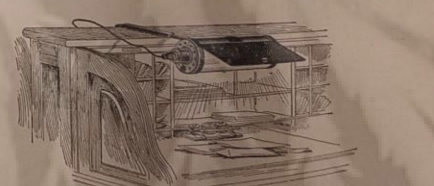
SHOWROOMS:
561 Broadway, N. Y.,
128 Essex St., Boston.

ELIZABETHPORT, N. J.

Beware of Spurious Imitations

OF THE

KINSMAN DESK LIGHT.



SEE THAT THE EYE SHADE IS ADJUSTABLE, so that an illumination of the room as well as of the desk can be obtained if desired.

SEE THAT ANY STANDARD LAMP MAY BE USED, as it is not only expensive but difficult to procure special shaped lamps.

SEE THAT YOU GET THE KINSMAN DESK LIGHT.

CAUTION. There are now a number of cheap and crude imitations of the **Kinsman** Desk Light on the market, one of which is being advertised with a similar cut. The Kinsman Desk Light was invented by Walter R. Kinsman, of Arlington, N. J. His invention was purchased outright by us, and has always been manufactured and sold by us. **Be careful** to see that the eye shade is adjustable, so that the room may be illuminated if desired; that there is a **revolving** glass cylinder with both ground and clear glass, so that you may get the full effect of the light, or it may be softened at pleasure, and **be especially careful** to see that any standard lamp up to 32 c.-p. may be used. Do not be misled by pictures on paper, but insist on seeing the goods.

McLEOD, WARD & CO.,

27 Thames Street, NEW YORK.

ILLUSTRATED
ELECTRICAL REVIEW
A Journal of Scientific and Electrical Progress.

VOL. 29. No. 23. WEEKLY.
NEW YORK, WEDNESDAY, DECEMBER 2, 1896.
$3 PER ANNUM. Single Copies, 10 Cents.

Entered at Post Office, New York, as Mail Matter of the Second Class.

VIEWS, NEWS AND INTERVIEWS.

In the early telephone days, a gentleman who afterward became prominent in the American Bell Telephone Company was sent into the West to examine the operation and management of several exchanges. In a small town he had occasion to criticise the operation of the local exchange, and observed that one of the operators was a very pretty girl, who seemed to be quite friendly with the manager, but who was not at all brisk about her work. Pointing her out, he said to the manager, quietly, "Who is that operator, and why do you keep her here?" The manager replied that she was very popular with the subscribers, and chiefly for that reason he kept her employed. "But she seems very slow in her work," said the inspector. "How do you account for that?" "Well," said the manager, "she is slightly deaf and stammers a little bit, but otherwise she is a very good operator."

A restaurant in Park Row, New York city, uses as an advertising device a large cake of clear ice in which a hole is made in the under side to accommodate a colored incandescent lamp. The light shining through the colored globe and the ice produces a beautiful effect even in the daytime. The color of the lamp used is varied from day to day. Altogether it is an effective scheme for attracting attention.

Superintendents in charge of electric plants operated by water power will be interested in the following tale concerning a cotton mill located on the Chattooga River, in Georgia. A few days since the superintendent of the mill discovered that there was something defective in the power, which is furnished by a turbine waterwheel. The water was shut off, so that an investigation could be made. The sluice gates were raised and the water drained from the canal and pier head, and the wheel-box was opened. Inside was found a mass of wriggling eels, weighing from one to four pounds each. They were so inextricably knotted and twisted around the shaft and among the blades of the wheel that the force of the water, although it amounts to several hundred horsepower, was insufficent to turn the machinery. The mill hands were summoned, and the work of removing the eels was begun. There were 160 eels, and the entire mass tipped the beam at 264 pounds.

It is said in the daily papers that an electrician has discovered a method of preserving eggs so that they will keep their freshness. He proposes to place the eggs in a vacuum chamber when fresh, and then, instead of absorbing outside air, the eggs will give it out until they are practically free from all air. When they have been in the vacuum chamber 48 hours they are to be painted with a composition that will keep them from absorbing any more air. But even at this stage decay has not been thoroughly arrested. The electrician then proposes to give them an electric bath. They are packed in barrels in which fresh water is poured, and a current of electricity is introduced sufficiently strong to destroy all animal life. All germs of decay are thus killed, and the eggs are ready for packing in sand or sawdust. As all decomposition has been destroyed, and the paint preservative keeps out the poisonous air, the eggs are supposed to keep for many months as fresh as when first laid.

Another instance of the deleterious effects of Roentgen rays on the tissues is reported in the *Deutsche Medicinische Wochenschrift*. A 13-year-old boy was exposed naked for 45 minutes to a very powerful apparatus, to have his picture taken. A fortnight later a circular red spot appeared on his abdomen; it grew and broke out into small itching blisters. After six weeks the irritation ended, but the discoloration had spread over the whole abdomen. The skin then scaled off, and after a while resumed its normal condition. The process was precisely the same as in a case of severe sun-burn.

A TROLLEY MAN-OF-WAR.

A Trolley Man-of-War.

The accompanying illustration from a daily paper shows a trolley man-of-war built in the shops of the Fitchburg & Leominster Street Railway Company, at Fitchburg, Mass. This pioneer of all land craft is not to be despised when it comes to a question of force. Dainty "barkers" peep out through her port holes, prototypes of the smiling faces that gleam from the sides of the flagship "New York." This trolley man-of-war, or white cruiser on wheels, has been dignified with the name of President-elect William McKinley. While her mission is not that of protection, so far, she is quite likely to be utiiized for that purpose in the days that are to come.

The McKinley is designed to run on electric roads of standard gauge, and it is very likely that the queer craft will have many imitations before long. She is, in appearance, a miniature, to a great extent, of the big cruisers that have followed Admiral Bunce's flag for so many months. Her superstructure is painted green, her hull and sponsons white, her guns and ironwork black. She carries 100 men, officers and crew, and is 37 feet long, nine feet wide, 12 feet high. The lines on which she was constructed were taken from the model of the battle-ship "Brooklyn" by Naval Architect Henry P. Lapointe.

Originally, the McKinley was a flat-car, and she was extended fore and aft so that finally her length from stem to stern was 37 feet. She has a double row of port holes on each side, and as she advances toward you, you see the sullen countenance of two grim six-pounders, while peeping from the tiny turret on the gun deck is a ferocious-looking 18-pounder. The craft is equipped with two 30-horse-power motors.

The builder believes that the McKinley demonstrates the fact that it is possible to construct a car for operation on street railroads in cities that would be of infinite use in case of riot. It is not beyond the range of the ability of modern mechanics to build a car that would be bullet proof and really constitute a traveling

Electrical Review

Times Building, 41 Park Row,
P. O. Box 2339. NEW YORK.

EDITOR:
CHARLES W. PRICE.
ASSOCIATE EDITOR:
STEPHEN L. COLES.

REGISTERED CABLE ADDRESS:
"ELECTVIEW," NEW YORK.

1546 "CORTLANDT," TELEPHONE CALL.

Subscription to the
ELECTRICAL REVIEW.

One Year, United States and Canada,	$3.00
One Year, Foreign Countries,	5.00
Single Copy,	.10

Copies can only be supplied for one year back at 25 cents each.

NEW YORK, DEC. 2, 1896.

CONTENTS.

INDEX OF ADVERTISERS.

There never was a better time than now for electrical manufacturers and dealers to inform the public of the merits of their goods. The best medium through which to accomplish this end is the advertising columns of the ELECTRICAL REVIEW. These two propositions require no argument.

TESLA'S LATEST CONTRIBUTION TO THE ROENTGEN-RAY PHENOMENA.

In this issue of the ELECTRICAL REVIEW we have the pleasure to bring to the attention of our readers another contribution on the subject of the Roentgen rays from the pen of Mr. Tesla, which, like all previous articles, conveys much useful and interesting information.

Mr. Tesla dwells on the nature of the rays, and brings out in strong relief some ideas and results which he has already recorded in our columns, and at the same time advances new observations and conclusions that can not fail to attract the attention of all workers in this new and fruitful field of investigation. We believe the possibilities pointed out of producing nitrogen compounds will prove of the greatest value.

The medical profession must indeed be indebted to Mr. Tesla for the valuable hints he gives for the application of Roentgen's discoveries to surgery.

His announcement of the real causes of the deleterious effects on the skin noted by a number of experimenters will be a welcome and timely revelation.

Mr. Tesla touches on the recently brought out and sensational subject of "making the blind see" by means of the Roentgen rays, presenting arguments and regretfully showing the hopelessness of such a task.

This latest communication will particularly interest the readers of the ELECTRICAL REVIEW by the wealth of the suggestions and important information it conveys.

STREET RAILWAY EMPLOYÉS AS STOCKHOLDERS.

The following is an abstract from an interesting editorial in the Buffalo *Commercial:*

That is an interesting and apparently judicious move the management of the Illinois Central Railroad Company is making in encouraging its employés to become stockholders in the corporation. The stock is offered monthly at a stated price, and on easy terms, any employé being permitted to apply for one share at a time, payable on pay-days in installments of $5 or any multiple thereof. This, of course, does not preclude the purchase by any employé of one or more shares for cash. Interest at the rate of five per cent per year is allowed on payments until the installments equal the price of the stock, when the dividend takes the place of the interest. In the event of the discontinuance of payments, the money is returned with accrued interest.

The objects of the plan are twofold: To benefit the company by giving its employés a direct, personal interest in the welfare of the road, and to benefit the employés by giving them a safe and profitable investment.

We say it is an apparently judicious move, because it is a plan the advantage of which, to the employé, depends largely on the solvency of the corporation, the nature of its business, competition, etc., and the character of its management.

The remarks quoted above are, of course, made in reference to steam railroads. We do not know that anything of the kind has ever been tried in connection with street railways. We believe, however, that the question is a fit subject for discussion, and would suggest that the next meeting of the American Street Railway Association would be a good place to discuss it.

Ohio is going to adopt electrocution in spite of many protests. The first test of the apparatus, just set up in the State Penitentiary at Columbus, was made on November 25, a large bull-dog being the victim. He was strapped in a chair exactly as a man would be, and the hair shaved from his body where the electrodes were applied. Fifteen hundred volts were turned on, and, naturally, the dog was killed. The machine will be tried in the presence of the prison managers, with a mule for a victim. The expert electrical knowledge of the prison management is shown in these tests, which prove, only to the managers let us hope, that the electrical resistance of any human being is a mean between that of a bull-dog and that of a mule. The Buckeye State surely has cause for shame.

THE FINANCIAL SIDE.

This has been a week of adjustment in the business world. Bank clearings decreased some 24 per cent as compared with last week, but are still some 7 per cent above returns of a year ago. The Associated Banks of New York show an increase of 14⅓ millions in deposits and over 8⅔ millions in loans. Since the election the increase in loans has been about 21¾ millions, which stands for that much business improvement. Prices of staples during the week moved somewhat irregularly. Metals, iron excepted, and cereals were higher. Iron is weak, owing to realization sales and the evident determination of business interests to hold off till the first of the year. The collapse in the nail and beam pool resulted in an increase in business.

The net loss in stock and bond values has been comparatively slight, and was due to reactionary influences. Nothing important marketwise is expected until Congress convenes, and its attitude towards the tariff and Cuban matters becomes known.

General Electric had a quiet week and was fully as firm as other stocks of its class. I understand that negotiations for the purchase of the Ft. Wayne outfit, which were undertaken some time ago, have been postponed. It has been the history of movements of this kind that they are always consummated when conditions in the stock market are opportune for a handsome turn. Just now the atmosphere is blue, at least for the moment, and the announcement that a deal has been consummated would fall flat. Upon the next bull swing in the market, advices from this quarter will be in order.

There was no feature in any of the other electrical stocks listed on the New York Stock Exchange. In Boston, Bell Telephone advanced some 2½ points to 209. Erie Telephone was steady at 63, and New England Telephone at 100. In Philadelphia, Electric Storage, common, closed unchanged at 29, and the preferred lost 1 point to 31. BAIN.

New York, November 28.

TESLA ON THE ROENTGEN STREAMS.

To the Editor of Electrical Review:

The following lines may contain some useful information for physicists and physicians. Those who, in the exercise of their professional duties, are applying the discoveries of Roentgen to the relief of the suffering by determining the position of foreign objects or ascertaining the condition of local troubles or malformations in the organism, are apt to be disappointed in many instances. While it is perfectly easy to find the position of a foreign object in the head, neck and all soft tissues of the body, and detect some far gone trouble in the lungs, often the location of even such a large and opaque object as a bullet, when imbedded in certain bony parts of the trunk of the patient, may be attended with difficulties. Success will be invariably attained if the suggestions which are given below, and which are the outcome of a number of observations of such cases, are strictly followed.

In order to make the present statements self-contained and more useful, I deem it of advantage to say a few words in regard to the Roentgen rays. According to all evidences so far obtained by me, I entertain the view, which I have expressed on other occasions, that these rays are formed by streams of some matter projected with great velocity, and generally intermittently, from the walls of the tube. The intermittent character is only due to this feature of the apparatus usually employed for the production of the rays; but the oscillatory or intermittent discharge is not absolutely necessary, as I have produced unidirectional currents of high tension which are likewise capable of generating strong rays, and as a static machine may be used with a like result. The mode of formation of these rays or streams is, for the present purposes, of little importance. The small particles within the bulb, which are the original cause, may be ions, formed by a process of electrolysis, or they may be comparatively larger particles of the electrode, or perhaps molecules of the residual gas. At any rate, it is probable that the particles are very minute, and that, therefore, the velocities of the cathodic streams within the vessel are such and the impacts so violent as to cause a further disintegration of the cathodic matter to a state probably never before studied by physicists. We may have to deal, as I have already suggested, with an actual breaking up of the ether-vortexes, which, according to Lord Kelvin's theory, compose the material particles, or we may be confronted with a dissolution of matter into some unknown primary form, the Akasa of the old Vedas. Experiments show that this matter is reflected, sometimes very well, sometimes poorly; but in all cases the various metals behave in a curious manner, which I have studied, and the results obtained, though probably not free of error, because of the great difficulties in getting an exact estimate in such an investigation, were, nevertheless, sufficiently positive as to lead me to the conviction that the same medium or element which is concerned in the setting up of the electro motive tension between metals in contact is present in the streams of Roentgen. It might have been proper to say, in the spirit of more modern views on contact electricity, that these streams are formed by ether, but I have preferred to use the term "primary matter;" for, although the expression "ether" conveys a perfectly definite idea to the scientific mind, there exists, nevertheless, much vagueness as to the structure of this medium. The matter projected is not revealed by spectral analysis, and it does not seem to produce any appreciable mechanical nor even heating effects, nor is it deflected by a magnet, all of which facts tend to show that it can not be composed of *molecules* of any known substance. The streams exercise a powerful action upon a photographic plate or fluorescent screen, but I look upon these results as obvious consequences of the energetic impact.

Of the various more or less plausible views in regard to the formation of these streams outside of the vessel, the simplest, to my mind, is to assume an actual projection through the walls of the bulb of the disintegrated cathodic matter. Granted that there are particles sufficiently small within the bulb, then all velocities, up to many thousands of kilometers per second, are not only possible, but also probable; and, even if the particles would not be further disintegrated by the impact against the wall or other comparatively opaque body within the bulb, they surely would penetrate through great thicknesses of most substances. My experiments in this direction have shown that all the disintegration is practically accomplished in the first impact against the more or less impenetrable obstacle within the bulb, the second impact having seemingly little effect, as might be inferred from well established mechanical principles. I have also found that the place of first and most energetic impact, be it the anode, cathode or wall of the vessel, is invariably the principal source of the rays or streams. Again, quite in accordance with mechanical principles, the penetrative power of the streams is the greater the more complete the disintegration. Thus, for instance, rays which have traversed thick opaque objects, and are presumably further disintegrated, pass more freely through dense substances. An observation to this effect has likewise been made by Professor Wright, who was the first to publish definite results in the United States. I find that bulbs with thick walls give rays of greater penetrating power. It should be, of course, understood that I do not mean by this a greater outward effect. It is principally the above fact which makes it appear more probable that the matter projected is not a *homogeneous stream*, but consists of particles of varied magnitude moving with different velocities, for, were the former the case, the penetrative power would depend chiefly on the velocity. In the practical use of the Roentgen streams it would, therefore, seem very important to find a method of filtering and rendering them homogeneous, for only by such a method can we hope to obtain exact results in their investigation. Streams of perfectly uniform velocity and character, if produced, would no doubt be more suitable for the purposes of research.

Since the disintegration of the electrodes, especially if they are of aluminum, is so slow that no appreciable diminution of the weight results even after long use; it follows that the matter conveyed by the Roentgen streams is so minute as to escape detection. Some bulbs, which I have used for a number of months, showed that the bombarded spot of the glass was entirely permeated with particles of the aluminum electrode, but it would probably require years of constant use to accumulate any appreciable amount of matter outside. Referring to a tube with an electrode of aluminum, it is a noteworthy fact that, if properly managed, it does not impair in quality, but, on the contrary, seems to improve; whereas, when a platinum electrode is used, the life of the bulb is very short, owing to the conductor being deposited on the walls, which deposit, as I have explained on another occasion, renders difficult the passage of the discharge. Namely, as soon as some of the projected particles strike the conducting layer, they impart a similar electrification to the latter, and a repulsion is exerted upon the particles following. The result is an apparent increase in the resistance of the tube. The above defect of the platinum electrode, despite of its effectiveness, must, in my opinion, lead to its abandonment.

It has been suggested that the Roentgen rays may be due simply to a propagation of electro-static stress; but, on this assumption, it is difficult to conceive how rays could be produced in instances when the glass wall is at a high temperature and consequently conducting, or when the impact plate or inclosure is of metal and connected to the ground. Stokes has recently considered the possibility that the impact of the cathodic stream on one side of a partition might give rise to a molecular motion on the other side without necessarily there being a transit through the partition. According to this view, which I have likewise considered some time ago, it would appear that the material streams might start on the outer side of the wall of the tube, in which case only the air would be responsible for the effects, and the futility of a spectral analysis test would be in a certain measure accounted for. But is it not more probable to assume an actual passage and shattering of matter, as all evidences point in this direction? Assuming that, as Professor Stokes now thinks it probable, the disturbance is non-periodic and still capable of producing effects characteristic of transverse vibrations of extremely high frequency, it seems to me a serious question whether the old Newtonian views on light should not be reconsidered rather than the conclusion drawn that the novel manifestations observed by Roentgen are due to transverse vibrations, when there is no experimental evidence to this effect, nor even a satisfactory explanation found how the cathodic impact might give rise to waves of a higher frequency than those of light.

Being, as I am, firmly convinced of the existence of material streams, I look upon the unsuccess of the attempts of demonstrating an actual transit of matter as being due to either the minuteness of the amount or else to the state of the matter, but rather to the former cause, as all peculiarities of the streams point in this direction. In my opinion, no experimenter need be deterred from carrying on an investigation of the Roentgen rays for fear of poisonous or generally deleterious action, for it seems reasonable to conclude that it would take centuries to accumulate enough of such matter as to interfere seriously with the process of life of a person. But I look confidently to the demonstration of actions of a purely qualitative nature. For instance, despite of the danger of such an assertion by encouragement which might be given to quacks, I would say that I expect with the utmost confidence the demonstration of a germicidal action. In addition to the physiological effects, to which I have early drawn attention, I have more recently observed with powerful tubes that a sensation of pain is produced in the forehead above the eyes just as soon as the current is turned on. This sensation is very similar to that one frequently experiences when stepping from a dark room into the glare of bright sunlight, or when walking for some time over fields of fresh-fallen snow.

As to the hurtful actions on the skin, which have been variously reported, I note that they are misinterpreted. These effects have been known to me for some time, but I have been unable, on account of pressing matters, to dwell on the subject. They are not due to the Roentgen rays, but merely to the ozone generated in contact with the skin. Nitrous acid may also be responsible, to a small extent. The ozone, when abundantly produced, attacks the skin and many organic substances most energetically, the action being no doubt heightened by the heat and moisture of the skin. After exposing the hand, for instance, for some time, the skin loses its elasticity, which causes a tension and pain, and subsequently an inflammation and blistering. This occurs mostly only at short range, but may be produced by a single terminal bulb, or generally by a very highly exhausted bulb, in which the terminals act independently, at greater distance. Owing to this, I have always taken the precaution, when getting impressions with the rays, to guard the person by a screen made of aluminum wires which is connected to the ground, preferably through a condenser. The radical means, however, of preventing such actions is to make impossible the access of the air to the skin while exposing, as, for instance, by immersing in oil. As this would be inconvenient in most cases, a metallic screen should be resorted to. The action of the ozone on some substances, when placed near the bulb in such a way that the gas is generated on their surfaces, is so powerful that the substances are practically destroyed in a few minutes. When a wire heavily insulated with rubber is connected to the terminal of a high-frequency coil, sometimes an exposure of barely a minute is sufficient to completely wreck the rubber insulation. There are certain commercial insulating compounds which are even more quickly destroyed, but which I will not enumerate, because of a possible disadvantage to the manufacturers. Gutta-percha, beeswax and paraffine stand the attack very well, and such

(Continued on page X.)

TESLA ON ROENTGEN STREAMS.

(Continued from page 277.)

wires should be used with high-frequency coils. This powerful action of the ozone was observed by me first about two years ago, when performing an experiment which was shown to many persons in my laboratory. The experiment consisted of charging a person, standing on an insulated stand, with a potential approximating one and one-half million volts, which was alternated several hundred thousand times a second. Under such conditions luminous streams break out on all parts of the body, especially abundantly on the feet, hands, hair, nose and ears. I subjected myself a number of times to this experiment, which seemed to offer no other danger except the possible rupture of a blood vessel, if the skin was very dry and non-conducting. I then noted on myself and others after effects resembling much those attributed to the Roentgen rays. With currents produced by perfected electrical oscillators, such as were described in one of your recent issues, [See ELECTRICAL REVIEW, September 30, 1896.—ED.] the production of the ozone is so abundant that it is sufficient to merely turn on the current for a few seconds and ozonize strongly the atmosphere of a large hall. These currents are also capable of bringing about chemical combinations, of which the chief is that of the nitrogen with the oxygen of the atmosphere, and an immense possibility, which I have been following up for a long time, is opened up; namely, the combination of the nitrogen of the atmosphere on an industrial scale by practically no other means than mechanical power. If merely fertilizers of the soil would be manufactured in this manner, the benefits to humanity derived therefrom would be incalculable. From the above-named action of the ozone, it follows that the experimenter should use the indicated precaution, for, while ozone in small quantities is a most beneficial disinfectant, when generated in large quantities it is not free of danger.

It is an unpleasant duty to say on this occasion a few words on the subject of "making the blind see" by means of the Roentgen rays. This sensational topic has been given a wide circulation in the journals. Is it not cruel to raise such hopes when there is so little ground for it? For, first of all, the rays are not demonstrated to be transverse vibrations. If they were, we would have to find means for refracting them to make possible the projection of a sufficiently small image upon the retina. As it is, only a shadow of a very small object can be projected. What possible good can result from the application of these rays to such purposes? The shape of the small object might eventually be recognized by impressing the retina, but the sense of touch is more than sufficient to convey such impressions. Luminous sensations are well known to be excited in two ways; namely, by mechanical shock and electrical transmission. Both of these, I think, are present in the Roentgen streams, and hence such an effect on the optic nerve might be expected. I may say, however, that I can not confirm some of the experiments reported. For instance, when a hand is put before the closed eyes it is easy to distinguish the shadow, much the same as before the light of a candle; but when the tube is inclosed, and all light from the same excluded, I fail to get such an impression. The latter is, therefore, chiefly due to ordinary light, or else my tubes act differently from those experimented with by others. It may be proper to recall here that in ordinary bright sunlight, especially in the southern climates, it is easy to distinguish the shadow of objects, and even their rough outlines, with the eyes shut.

Proceeding on the assumption that we have in reality to deal with material streams, it is important to inquire which are the best conditions to be maintained when taking impressions with the sensitive screen or plate. First, the experimenter will easily observe that there are two causes which, with a given bulb and coil, tend to increase the intensity of the impressions. One of these may be said to lie in the bulb, the other in the coil. The latter, being most generally made of many turns of fine wire, is very sensitive to changes in the capacity of bodies attached to its terminals. The capacity of these bodies, therefore, in such a coil largely determines the difference of potential. At a certain degree of exhaustion this capacity assumes such a value that the pressure rises to a maximum, this tending to give the highest velocity to the cathodic stream, and, consequently, to give rise to the most intense rays. But at that degree of exhaustion it may happen, and usually does happen, that the cathodic streams are not most abundant. To produce the best result it is necessary that both of these causes should be made to co-operate by a careful proportioning of the dimensions of the bulb, which, in practice, is very difficult, inasmuch as the experimenter has to avail himself of commercial bulbs which may or may not be best suitable for his coil. This simple consideration shows the great advantage of the use of a coil which contains no fine wire and is capable of giving a heavy current through the secondary far in excess of what even the largest bulb requires.

Assuming the physician has learned how to manipulate his apparatus to best advantage, he will next notice that, to secure the clearest definition, he will have to maintain a certain pressure on the terminals of the tube, dependent chiefly on the distance and degree of opacity of the object investigated. It goes without saying that the definition is the better the smaller the spot from which the rays are emanating, but this is true only when impressions are taken at very small distances. When the distances are large, it is a disadvantage to use a too small radiating surface, as then the density is diminished to such a degree that the action is too weak. Discarding this consideration, it is clear that, if the rays are intense, the more opaque portions of the body are likewise penetrated and much detail is lost, whereas, when the rays are less intense, the impression might be altogether too weak to bring out sufficient detail.

To illustrate in a popular manner the best way to proceed, I shall avail myself of a simple illustration. Suppose that there would be imbedded between two panels of cloth a foreign object, such as a coin, and it is desired to locate it. We may accomplish this by placing behind the cloth a cardboard, for instance, and then firing from a certain distance a load of fine shot through the cloth in the region where the coin is supposed to be located. The shot will penetrate the cloth on all points except on the place where the coin is located, and on the cardboard behind, this place will be plainly indicated by the absence of the marks. Exactly in this way we proceed in applying the Roentgen rays to the location of such a body. Roentgen gave us a gun to fire—a wonderful gun, indeed, projecting missiles of a thousandfold greater penetrative power than that of a cannon ball, and carrying them probably to distances of many miles, with velocities not producible in any other way we know of. These missiles are so small that we may fire them through our tissues for days, weeks, months and years, apparently, without any hurtful consequence. Instead of the cardboard to indicate the path of the missiles, he gave us what is properly called a Roentgen screen, which becomes luminous on all places where it is hit by the missiles. Where the latter are prevented from hitting the screen by the intervention of the opaque body, the screen does not glow and we observe the shadow of the object. It is simple enough to project the shadow of an object in this way, but when it is required to show the finer detail of the structure of the object, the difficulty begins. It will at once appear that, to produce such a result to best advantage, two conditions will have to be more or less realized. Firstly, the screen should be composed of such material that it is capable of becoming luminous by the *faintest impact*; and, secondly, the missiles should all be of uniform size, and should move with uniform velocity. Neither of these two conditions has so far been realized in practice, for all the bodies we know require a violent impact to become luminous, and no way has been found as yet to produce a uniformity in velocity and magnitude of the supposed projectiles. But a little thought leads immediately to the conclusion that there will be a certain velocity of the missiles which will give, under all conditions, the best definition. This velocity is easily ascertained by trial. Evidently the definition will be best when the bullets which pass through the densest parts of the body strike the screen so feebly as to not make it light up, whereas, those passing through portions of slightly smaller density hit it sufficiently strong as to make it light up feebly. The more sensitive the screen to impact, that is, the weaker an impact is required to make the screen light up, the more detail will be revealed. It therefore follows that, in the application of the Roentgen rays, not the body which fluoresces strongest, but the one which is most sensitive, is best suited for finer work.

The above considerations have led me to adopt the following procedure, which, in practice, has proved very successful. The Roentgen screen is first applied to the body to be investigated, the pressure at the terminals of the tube being very much reduced. The pressure is then slowly and gradually raised. It will be presently observed that, at a certain pressure, the shadow of the object examined is clearest. But as the vacuum is increasing, the pressure generally rises, and the image gets blurred in spite of the screen getting much brighter. Just as soon as the clearness is slightly diminished, the experimenter should for a few moments reverse the current, lowering a little the vacuum in this manner. The current being again given the direction it had at first, namely, that which causes a slow and steady increase of the vacuum, the shadow gets again clear, and by such easy manipulation the best result may be secured. An additional advantage, however, is gained, because the frequent reversals produce a brighter phosphorescence of the screen. When taking a photograph, the bulb should be watched through the screen and the switches manipulated in the above manner.

To give a practical example of the effectiveness of this procedure, I need only mention one of the instances which have come to my notice. A few months ago I investigated the case of Mr. Cornelius Mack, of Watertown, Mass. Mr. Mack, while performing his duties many years ago, was struck by a bullet which lodged somewhere in the chest and could not be located. I applied the screen vainly a number of times, for although the streams penetrated the body with such ease as to make the screen behind appear bluish white, and reveal all the bones of the body, I could not observe the missile. I then resorted to the above indicated means, and immediately and easily the exact location of the projectile, between the shoulder blade and one of the ribs, was ascertained and the bullet successfully extracted. NIKOLA TESLA.

New York, November 30.

TESLA ON ROENTGEN STREAMS.

(Continued from page 277.)

wires should be used with high-frequency coils. This powerful action of the ozone was observed by me first about two years ago, when performing an experiment which was shown to many persons in my laboratory. The experiment consisted of charging a person, standing on an insulated stand, with a potential approximating one and one-half million volts, which was alternated several hundred thousand times a second. Under such conditions luminous streams break out on all parts of the body, especially abundantly on the feet, hands, hair, nose and ears. I subjected myself a number of times to this experiment, which seemed to offer no other danger except the possible rupture of a blood vessel, if the skin was very dry and non-conducting. I then noted on myself and others after effects resembling much those attributed to the Roentgen rays. With currents produced by perfected electrical oscillators, such as were described in one of your recent issues, [See ELECTRICAL REVIEW, September 30, 1896.—ED.] the production of the ozone is so abundant that it is sufficient to merely turn on the current for a few seconds and ozonize strongly the atmosphere of a large hall. These currents are also capable of bringing about chemical combinations, of which the chief is that of the nitrogen with the oxygen of the atmosphere, and an immense possibility, which I have been following up for a long time, is opened up; namely, the combination of the nitrogen of the atmosphere on an industrial scale by practically no other means than mechanical power. If merely fertilizers of the soil would be manufactured in this manner, the benefits to humanity derived therefrom would be incalculable. From the above-named action of the ozone, it follows that the experimenter should use the indicated precaution, for, while ozone in small quantities is a most beneficial disinfectant, when generated in large quantities it is not free of danger.

It is an unpleasant duty to say on this occasion a few words on the subject of "making the blind see" by means of the Roentgen rays. This sensational topic has been given a wide circulation in the journals. Is it not cruel to raise such hopes when there is so little ground for it? For, first of all, the rays are not demonstrated to be transverse vibrations. If they were, we would have to find means for refracting them to make possible the projection of a sufficiently small image upon the retina. As it is, only a shadow of a very small object can be projected. What possible good can result from the application of these rays to such purposes? The shape of the small object might eventually be recognized by impressing the retina, but the sense of touch is more than sufficient to convey such impressions. Luminous sensations are well known to be excited in two ways; namely, by mechanical shock and electrical transmission. Both of these, I think, are present in the Roentgen streams, and hence such an effect on the optic nerve might be expected. I may say, however, that I can not confirm some of the experiments reported. For instance, when a hand is put before the closed eyes it is easy to distinguish the shadow, much the same as before the light of a candle; but when the tube is inclosed, and all light from the same excluded, I fail to get such an impression. The latter is, therefore, chiefly due to ordinary light, or else my tubes act differently from those experimented with by others. It may be proper to recall here that in ordinary bright sunlight, especially in the southern climates, it is easy to distinguish the shadow of objects, and even their rough outlines, with the eyes shut.

Proceeding on the assumption that we have in reality to deal with material streams, it is important to inquire which are the best conditions to be maintained when taking impressions with the sensitive screen or plate. First, the experimenter will easily observe that there are two causes which, with a given bulb and coil, tend to increase the intensity of the impressions. One of these may be said to lie in the bulb, the other in the coil. The latter, being most generally made of many turns of fine wire, is very sensitive to changes in the capacity of bodies attached to its terminals. The capacity of these bodies, therefore, in such a coil largely determines the difference of potential. At a certain degree of exhaustion this capacity assumes such a value that the pressure rises to a maximum, this tending to give the highest velocity to the cathodic stream, and, consequently, to give rise to the most intense rays. But at that degree of exhaustion it may happen, and usually does happen, that the cathodic streams are not most abundant. To produce the best result it is necessary that both of these causes should be made to co-operate by a careful proportioning of the dimensions of the bulb, which, in practice, is very difficult, inasmuch as the experimenter has to avail himself of commercial bulbs which may or may not be best suitable for his coil. This simple consideration shows the great advantage of the use of a coil which contains no fine wire and is capable of giving a heavy current through the secondary far in excess of what even the largest bulb requires.

Assuming the physician has learned how to manipulate his apparatus to best advantage, he will next notice that, to secure the clearest definition, he will have to maintain a certain pressure on the terminals of the tube, dependent chiefly on the distance and degree of opacity of the object investigated. It goes without saying that the definition is the better the smaller the spot from which the rays are emanating, but this is true only when impressions are taken at very small distances. When the distances are large, it is a disadvantage to use a too small radiating surface, as then the density is diminished to such a degree that the action is too weak. Discarding this consideration, it is clear that, if the rays are intense, the more opaque portions of the body are likewise penetrated and much detail is lost, whereas, when the rays are less intense, the impression might be altogether too weak to bring out sufficient detail.

To illustrate in a popular manner the best way to proceed, I shall avail myself of a simple illustration. Suppose that there would be imbedded between two panels of cloth a foreign object, such as a coin, and it is desired to locate it. We may accomplish this by placing behind the cloth a cardboard, for instance, and then firing from a certain distance a load of fine shot through the cloth in the region where the coin is supposed to be located. The shot will penetrate the cloth on all points except on the place where the coin is located, and on the cardboard behind, this place will be plainly indicated by the absence of the marks. Exactly in this way we proceed in applying the Roentgen rays to the location of such a body. Roentgen gave us a gun to fire—a wonderful gun, indeed, projecting missiles of a thousandfold greater penetrative power than that of a cannon ball, and carrying them probably to distances of many miles, with velocities not producible in any other way we know of. These missiles are so small that we may fire them through our tissues for days, weeks, months and years, apparently, without any hurtful consequence. Instead of the cardboard to indicate the path of the missiles, he gave us what is properly called a Roentgen screen, which becomes luminous on all places where it is hit by the missiles. Where the latter are prevented from hitting the screen by the intervention of the opaque body, the screen does not glow and we observe the shadow of the object. It is simple enough to project the shadow of an object in this way, but when it is required to show the finer detail of the structure of the object, the difficulty begins. It will at once appear that, to produce such a result to best advantage, two conditions will have to be more or less realized. Firstly, the screen should be composed of such material that it is capable of becoming luminous by the *faintest impact*; and, secondly, the missiles should all be of uniform size, and should move with uniform velocity. Neither of these two conditions has so far been realized in practice, for all the bodies we know require a violent impact to become luminous, and no way has been found as yet to produce a uniformity in velocity and magnitude of the supposed projectiles. But a little thought leads immediately to the conclusion that there will be a certain velocity of the missiles which will give, under all conditions, the best definition. This velocity is easily ascertained by trial. Evidently the definition will be best when the bullets which pass through the densest parts of the body strike the screen so feebly as to not make it light up, whereas, those passing through portions of slightly smaller density hit it sufficiently strong as to make it light up feebly. The more sensitive the screen to impact, that is, the weaker an impact is required to make the screen light up, the more detail will be revealed. It therefore follows that, in the application of the Roentgen rays, not the body which fluoresces strongest, but the one which is most sensitive, is best suited for finer work.

The above considerations have led me to adopt the following procedure, which, in practice, has proved very successful. The Roentgen screen is first applied to the body to be investigated, the pressure at the terminals of the tube being very much reduced. The pressure is then slowly and gradually raised. It will be presently observed that, at a certain pressure, the shadow of the object examined is clearest. But as the vacuum is increasing, the pressure generally rises, and the image gets blurred in spite of the screen getting much brighter. Just as soon as the clearness is slightly diminished, the experimenter should for a few moments reverse the current, lowering a little the vacuum in this manner. The current being again given the direction it had at first, namely, that which causes a slow and steady increase of the vacuum, the shadow gets again clear, and by such easy manipulation the best result may be secured. An additional advantage, however, is gained, because the frequent reversals produce a brighter phosphorescence of the screen. When taking a photograph, the bulb should be watched through the screen and the switches manipulated in the above manner.

To give a practical example of the effectiveness of this procedure, I need only mention one of the instances which have come to my notice. A few months ago I investigated the case of Mr. Cornelius Mack, of Watertown, Mass. Mr. Mack, while performing his duties many years ago, was struck by a bullet which lodged somewhere in the chest and could not be located. I applied the screen vainly a number of times; for although the streams penetrated the body with such ease as to make the screen behind appear bluish white, and reveal all the bones of the body, I could not observe the missile. I then resorted to the above indicated means, and immediately and easily the exact location of the projectile, between the shoulder blade and one of the ribs, was ascertained and the bullet successfully extracted. NIKOLA TESLA.

New York, November 30.

Kindred.... ...Interests

The Kent Electric Manufacturing Company, Worcester, Mass., has issued a neat catalogue illustrating and describing its alternating-current motors, battery motors and light power specialties.

G. A. Frei & Company, 17 Bromfield street, Boston, Mass., have recently prepared a very satisfactory and complete catalogue of their X-ray supplies, which also contains a number of flattering testimonials as to the merit of their apparatus. The catalogue may be had for the asking.

The Electric Appliance Company, Chicago, report a splendid lamp business during the months of October and November. The Packard lamp not only holds its own, but gains ground every year in a way that indicates clearly that it is made of the right kind of stuff and has lasting merit.

McKenney & Waterbury, Boston—Large contracts for gas and electric fixtures received the past week by Messrs. McKenney & Waterbury, Franklin street, included the City Hospital building, Massachusetts Benefit Association building, State street; Storage Warehouse building, Huntington avenue; Odd Fellows' building, Gardiner, Me.; Fitchburg Normal School, and the South Congregational Church, Concord, N. H. This firm is the largest in the business in New England.

The Phillips Insulated Wire Company, Pawtucket, R. I., are sending out a remarkably handsome and complete price list, as well as neatly prepared samples of their fire and weatherproof wire, underwriters' wire and Ideal wire, all of which they make in addition to their celebrated "O. K." weatherproof insulated wire. They are calling especial attention to their Ideal wire, with a black insulation and white fireproof outside finish. This latter wire is adapted for exposed work where a good white finish is desired.

Probably no other among the many unique businesses conducted in the city of New York is better known or has a wider field of usefulness than the Manufacturers' Advertising Bureau. This concern was established in 1879 by its present head and proprietor, Benj. R. Western, formerly publisher of the *Engineering and Mining Journal*, the *Manufacturer and Builder* and *Coal and Iron Record*, all of New York. Its purpose is the management of the newspaper work and advertising for manufacturers, and its long connection and intimate relations with the class press in all parts of the United States enable it to bring to its work an experience and knowledge that insures the best possible results. The present location of the Manufacturers' Advertising Bureau—126 Liberty street—is an admirable one, and affords the best of facilities for transacting its business in a satisfactory and expeditious manner.

ADVANCE INFORMATION

Valuable News and Tips for Manufacturers and Dealers.

We publish below information relating to new electric railways, new electric light companies, new telephone companies and projected electric construction of all kinds. Every reader will find these columns of special interest, and manufacturers and supply houses will receive many valuable suggestions looking to new business by carefully watching this department in the Electrical Review.

Electric Light and Power.

Bellows Falls, Vt.—The Westminster Electric Company has been incorporated by George O. Guild, Benjamin B. Wetherbee, Charles K. Labaree and others, for the purpose of establishing an electric plant at Westminster, in Windham County. Capital stock, $50,000.

Philadelphia, Pa.—Joseph J. DeKinder can give information concerning proposed construction of good municipal plant.

Des Moines, Iowa—Mayor MacVicar can give information concerning establishment of electric light plant to be built and owned by the city.

Coal Creek, Tenn.—R. M. Edward & Company are interested in proposed erection of electric light plant.

Cameron, Mo.—An electric light plant will be constructed at a cost of $12,000. They are in the market for the necessary machinery.

Cranston, R. I.—Town Clerk may give information concerning the establishment of proposed electric light plant.

Hardwick, Vt. — The electric light plant is rapidly approaching completion.

Jacksonville, Fla.—A. P. Weller, of the Tarpon Springs Electric plant, will purchase material necessary for the completion of the electric light plant at St. Petersburg.

Barre, Vt.—Barre Electric Light and Power Company has been incorporated by Frank G. Howland, H. K. Bush, W. A. Perry, Geo. J. Reynolds. Capital stock, $150,000.

Fort Worth, Tex. — Standard Light and Power Company has been incorporated by John C. Harrison, Wm. B. Harrison, George E. White, R. I. White. Capital stock, $100,000.

Youngstown, Ohio—A new electric light plant is to be established.

Fairhaven, Mass.—It is reported that Mr. Joseph Nye, of this place, will erect an electric light plant.

Riverside, Cal.—The City Trustees are discussing the matter of making further extensions of the city's electric system, the engineer having been called on for estimates of cost.

Los Angeles, Cal.—The West Side Lighting Company has been incorporated. Directors are E. E. Peck, E. F. Billmeyer, of Los Angeles; George H. Baker, W. R. Staats and Walter S. Wright, of Pasadena.

Beaver Falls, Pa.—The charter of the Valley Power and Light Company has been entered for record in the Recorder's office. The incorporators are Wm. A. McCool, president; Hunter Eckert, secretary; H. M. Reeves, treasurer; A. S. Reeves and J. M. Breamer. The latter two are of Philadelphia. The company is capitalized at $3,000.

Southbridge, Mass. — Agitation of the subject of lighting the town by electricity is started, and the Southbridge electric plant has it under consideration.

San Francisco, Cal.—There is more than a probability that a portion of this year's appropriation for Golden Gate Park will be used for the purpose of lighting the park with electricity.

Ophir, Colo.—Final plans are about completed for a system of electric lighting for this place. The power will be furnished by the Dunn power plant at Ames.

Millstodt, Mo.—An electric light plant, to cost $8,000, is to be erected here.

New Electric Railways.

Poultney, Vt.—The Western Vermont Street Railway Company applied for articles of incorporation to operate a street railway in the towns of Middletown Springs, Poultney, etc. Incorporators are Leonidas Gray, A. Y. Gray, A. A. Greene, A. H. Varney, J. B. Beaman, E. H. Phelps and Jerome B. Bromley. Capital stock, $100,000.

Topeka, Kas.—The Pittsburgh, Weir City & Columbus Railway Company has been organized by Robert Simons, John A. Nuttman, J. M. Leipman, John Randolph and Sam Barratt, to build and operate a steam or electric railroad in Cherokee and Crawford counties. Capital stock, $200,000.

Racine, Wis. — The Milwaukee, Racine & Kenosha Electric Railway Company has been incorporated, to operate an electric street railway system from South Milwaukee, northerly through Cudahy and the towns of Lake and Oak Creek, then south through the towns of Caledonia and Oak Creek, then south through the towns of Caledonia and Mount Pleasant, city of Racine and the towns of Somers, Pleasant Prairie and city of Kenosha. Capital stock, $250,000.

New York, N. Y.—A permit has been granted to the Third Avenue Railroad Company to extend its tracks from 162d street along Kingsbridge Road and Broadway to Spuyten Duyvil Creek, and to use the trolley electric-motive power.

Mt. Clemens, Mich.—An ordinance has been introduced in the council granting a franchise to the Detroit, Lake Shore & Mt. Clemens Railroad, to operate an electric railway in this city over the tracks of the Mt. Clemens Traction Company's track.

Hamilton, Ohio—A 50-year franchise has been granted to the Cincinnati & Miami Valley Traction Company to operate their lines through this county. Work must be begun by July, 1897.

Portsmouth, Ohio—An electric line from Sciotoville to New Boston will be built in the Spring.

New Telephone and Telegraph Companies.

Jefferson City, Mo.—The Underground Telegraph and Telephone Company, the successor of the Sutter Subway Company, has been incorporated. Incorporators are Charles Sutter and Emil Meysenburg.

Ellicott City, Md.—A stock company is being organized in Howard County for the purpose of establishing an extensive telephone system in this county. The proposed line is to connect Gaithers, Hood's Mill, Cooksville, Glenwood, Gary, Roxbury Mills and Sunshine, and ultimately to reach Lisbon, Poplar Springs, Mt. Airy, Long Corner, Florence, Daisy, Gleneig, Dayton, Highland, Clarksville, Guilford, Columbia, Ellicott City, Mayfield, Pine Orchard, West Friendship, Alpha, Mt. View, Sykesville and other points.

Laramie, Wyo.—The matter of building a telephone line from this place to North Park is being again agitated.

Jefferson, Ohio—The independent line which is being constructed between this place and Warren will, upon its completion, be connected with the lines of the Youngstown Telephone Company, with the establishment of exchanges at Girard and Niles.

New Manufacturing Companies.

St. Louis, Mo.—The Electric Push Button Manufacturing Company has been incorporated; capital stock, $50,000. Incorporators: Anthony Silverston, W. Y. Hopkins and C. M. Napton.

the Cin-
Traction
eir lines
rk must

electric
w Boston

elegraph

e Under-
elephone
he Sutter
en incor-
Charles
g.
ock com-
Howard
ablishing
m in this
is to con-
, Cooks-
ury Mills
to reach
It. Airy,
Daisy,

$50,000. Incorporators: Anthony Silverston, W. Y. Hopkins and C. M. Napton.

IMPROVED

ROENTGEN-RAY APPARATUS

Fluorescent Screens,
Fluoroscopes,
Calcium Tungstate Crystals,
Scientific and Electrical Instruments,
Special Apparatus to Order.

Sole Manufacturers of the new

NON-PHOSPHORESCENT

HIGHLY FLUORESCENT CRYSTALS.

Superior to Calcium Tungstate; perfect definition; instantaneous work; each new image undimmed by phosphorescence or previous exposure.

Spring Park Laboratory,

38 Spring Park Avenue,
JAMAICA PLAIN, MASS.

Y GENUINE

Lake and Oak Creek, then south through the towns of Caledonia and Oak Creek, then south through the towns of Caledonia and Mount Pleasant, city of Racine and the towns of Somers, Pleasant Prairie

---

X-RAY SUPPLIES.

CROOKES TUBES.
FLUOROSCOPES.

Stanley's TOEPLER-HOLTZ Machines

will do same work as high-frequency coil at

ONE QUARTER FIRST COST,

With no Installation or Running Expenses.

Send for descriptive pamphlet and prices. They will surely interest you.

Tungstate of Calcium
Photographic Screens.

G. A. FREI & CO.,

17 Bromfield Street, BOSTON.

and Sunshine, and ultimately to reach Lisbon, Poplar Springs, Mt. Airy, Long Corner, Florence, Daisy,

38 Spring Park Avenue,
JAMAICA PLAIN, MASS.

Company, Worcester, Mass., has issued a neat catalogue illustrating and describing its alternating-current motors, battery motors and light power specialties.

G. A. Frei & Company, 17 Bromfield street, Boston, Mass., have recently prepared a very satisfactory and complete catalogue of their X-ray supplies, which also contains a number of flattering testimonials as to the merit of their apparatus. The catalogue may be had for the asking.

The Electric Appliance Company, Chicago, report a splendid lamp business during the months of October and November. The Packard lamp not only holds its own, but gains ground every year in a way that indicates clearly that it is made of the right kind of stuff and has lasting merit.

McKenney & Waterbury, Boston

ILLUSTRATED
ELECTRICAL REVIEW
A Journal of Scientific and Electrical Progress.

VOL. XXX.—No. 4.
Copyright, 1897, by ELECTRICAL REVIEW PUB. CO.
NEW YORK, WEDNESDAY, JANUARY 27, 1897.
TEN CENTS A COPY.
THREE DOLLARS A YEAR.

ILLUSTRATED
ELECTRICAL REVIEW
A Journal of Scientific and Electrical Progress.

VOL. 30. No. 4. WEEKLY. | NEW YORK, WEDNESDAY, JANUARY 27, 1897. | $3 PER ANNUM. Single Copies, 10 Cents.

 Entered at Post Office, New York, as Mail Matter of the Second Class.

VIEWS, NEWS AND INTERVIEWS.

Mr. Andrew Carnegie is occupying, for the Winter, the handsome residence of Mr. E. H. Johnson, president of the Interior Conduit and Insulation Company, at Greenwich, Ct.

The Cosmopolitan Electric Company, of Chicago, has come to life again, and last week secured permission to lay conduits in the downtown district. If the company's plans are successfully carried out it will become a direct competitor of the Chicago Edison company.

The Appellate Division of the New York State Supreme Court has decided that a woman could not recover damages from the Western Union for the grief and anguish caused by the delay of a message which prevented her attending her brother's funeral. In his opinion Justice Barrett said: "There is, in fact, no congruity between pecuniary loss and isolated mental pain."

The directors of the Union Traction Company, of Philadelphia, have adopted the recommendation of the executive committee to call an installment of $2.50 per share on the stock, payable March 1. The company's books will close on February 10 and reopen on March 2.

The syndicate which has purchased the Long Island Railroad has engaged President Vreeland, of the Metropolitan Street Railway Company, of New York city, to make a physical examination of the Long Island property.

While two employés of the Metropolitan Street Railway Company, of New York city, were delivering bags of money to a Broadway bank one day last week, a smart thief came along and carried off a bag containing $5,600.

Omaha, Neb., has 95 miles of cable and electric street railway, the longest line being nine miles.

Electricity in Paterson, N. J.

The Edison Electric Illuminating Company of Paterson, N. J., believing that a better knowledge of the applications and simple laws governing the electric current would be of interest to their customers and further their business, their general manager, Mr. William Brock, has written a book for distribution in which he has given a concise and clear elementary statement of the A B C principles of the science. The explanations are ingeniously made by a practical man, and the stereotyped analogies are conspicuous by their absence, and the book is well illustrated. The Electrical Review acknowledges the receipt of a copy.

ELECTRIC LIGHTING IN TASMANIA.

AN INTERESTING ELECTRICAL-WATER-POWER INSTALLATION.

Messrs. Siemens Brothers, the well known London electrical firm, have recently completed an interesting electrical-water-power installation, which is now furnishing current to Launceston, Tasmania. For the accompanying illustration and the following description of this interesting plant we are indebted to our London namesake: The site fixed for the generating station is three miles from the center of Launceston, but there is no road to the place. The building material was prepared at one side of the river and slung across on a wire rope tramway; the machinery, however, had to be taken round a distance of seven miles through the bush, but that only brought it to the top of a steep hill, about 500 feet in height, down which the whole of the plant had to be lowered.

Electric Lighting in Tasmania.—Water-Power Plant Which Furnishes Current to Launceston. The Picture Shows the River in Flood.

Ever since Launceston was first settled, the residents recognized that great power was available from the South Esk River, which rushes in a series of cataracts for miles above the gorge, where it joins its waters with those of the North Esk, to form the River Tamar. Driving machinery for flour-mill purposes was the only application of the enormous force offering itself until comparatively late years, when enterprising citizens, hearing of what was being done in other countries, began to talk of using the water power for the generation of electricity.

The City Surveyor, Mr. David, after considering various propositions, decided to tap the river at a certain point, already determined, by driving through a bend to a spot some 90 chains above first basin, which would give him sufficient fall. He found the plan quite practicable, and that it would be far superior to the pipe-track scheme, inasmuch as the tunnel, once made, would entail practically no maintenance cost, and would be free from the objection which those acquainted with the banks of the South Esk at the point concerned know to be a serious one; that interruptions, vexatious while they last and costly to set right, would be caused by rocks and trees falling onto the pipes. The cost of this scheme, including the necessary dams and other extraneous works, was estimated at £13,169. The dams and race were put in, under Mr. David's personal superintendence, by day labor, at a cost of £1,312. It was freely asserted that the tunnel could not be driven for double the estimated cost, that it would occupy three years in driving, etc., objectors basing their arguments upon the cost of driving in similar country elsewhere. Events proved the unreliability of the objectors' data, as the drive was put through in 16 months'

actual working time, driving from both ends; and when on March 28, 1895, the men working from the two ends met, the engineer had the satisfaction of finding that his levels had been less than an inch out. The actual cost of the tunnel proved to be £11,913, or with dams, etc., a total of £13,225, as against £13,169 estimated.

The grade of the tunnel is one in 110, calculated to give a velocity of about 10 feet per second, and therefore a discharge of about 11,780 cubic feet per minute; but as by Parliamentary restrictions only two-thirds of the water flowing in the river is to be made use of, that quantity, equal to 10,000 cubic feet per minute, is all that can be depended on during dry Summer weather.

The resulting horse-power, taking 10,000 cubic feet per minute as a basis, is 1,562, at 75 per cent efficiency of turbine, and costs, therefore, £6 10s. per horse-power, a rate which compares very favorably with similar work in any part of the world.

From a screening chamber the water, after being strained, is conveyed to the power-station by a pipe-line. The pipe is of wrought-iron, with flanged joints, is one-quarter-inch thick, and for the first 82 feet is five feet in diameter, the remaining 121 feet being four feet in diameter. The lower end is expanded into a bell mouth, six feet by two feet six inches. The bell mouth carries the water to a wrought-iron receiver 88 feet long, which extends along the back of the power-house. The central portion, 41 feet in length, is six feet in diameter, and is of wrought-iron three-eighths-inch thick; the two end portions being three feet in diameter and one-quarter-inch thick, all being held back by one and one-half-inch anchor bars. The receiver is fitted with four four-inch dead-weight safety valves.

From the six-feet section the water is led into the building by means of four two-feet four-inch pipes, and from the three-feet sections by six 12-inch pipes, though only three of the former and five of the latter are at present in use, one of each being left for future extensions. The water from these pipes is taken directly to the turbines, draft tubes being made use of to insure at least 110 feet of working head.

The generating station is situated above highest known flood mark on the river bank. It is built of the local basalt on concrete foundations, and with galvanized iron roof; is 105 feet by 24 feet in the clear, with a central bay of 40 feet, which is six feet wider. The height of the wings is 15 feet, and of the center 22 feet; to the wall plate in each case. The tail-race extends nearly the entire length of the building, is nine feet wide and 12 feet deep, and was excavated in the solid basalt. It is arched over with concrete, on which are bedded the girders to which the turbines and other machinery are bolted. The building, including foundations, cost £1,838.

The bid of Messrs. Siemens Brothers for the electrical plant, including maintenance for six months, was £32,000. The contractors arranged with Mr. Dunk, of Sydney, owner of a patent pole-trimming machine, to bring one of his machines to Launceston and trim all the poles to the form decided upon by the superintending engineer. The specification contemplated trimming the poles by manual labor, but the contractors were desirous to make them look well, and as only by the use of the machine could they be given that smooth and finished appearance which has been so admired in Launceston, the extra expense was not minded. After being trimmed to shape, octagonal from the ground line to eight feet above that line, and circular thence to the top with proper taper, the poles were mortised and the arms fitted into them, then a coat of paint given, and they were carted away to the site of their permanent position.

The machinery fitted only takes up about 400 out of the 1,560 horse-power available, the water running through the tunnel supplies; so that water is available without extra cost to drive nearly four times as much machinery as has been arranged for at the start. The water pipes from tunnel and the building are arranged to accommodate about 50 per cent more effective alternating plant and 25 per cent more arc-lighting plant. There are eight Thomson Vortex turbines at work, fitted with the Murray hydraulic governor. They are adapted for a fall of 110 feet, and arranged for coupling direct to the dynamos. Five of the turbines drive arc-light dynamos at 800 revolutions a minute, at which speed they each give 21 horse-power. The other three drive alternators at 460 revolutions a minute, and each gives 158 horse-power.

The arc-light dynamos are of Siemens Brothers' manufacture, and give a constant current of seven amperes and an electro-motive force of 1,750 volts when running at 800 revolutions a minute. The armatures are of the ring type and wire wound. The electro-magnets are of the double magnetic circuit type, made of the very best wrought-iron, and are series wound. They are driven direct by the turbines. In Launceston there are in use 120 Siemens "band" arc lamps, taking seven amperes, and burning for 16 hours without retrimming.

LITERARY.

McClure's Magazine for February will contain some Kansas stories by William Allen White, the young editor of the Emporia *Gazette*, whose recent editorial, "What's the Matter with Kansas?" attracted so much attention.

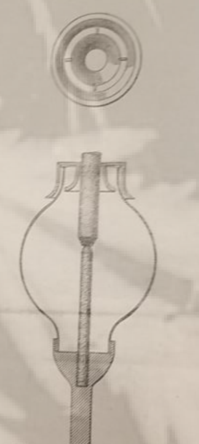
City Government is the title of a new monthly publication, of handsome typographical appearance, devoted to the practical affairs of municipalities. It covers a new field, and has received the indorsement of many prominent city officials. The paper is published by the City Government Publishing Company, 150 Nassau street, New York city. Mr. Clarence E. Stump, formerly well known in electrical journalism, is the president and treasurer of the company.

THE INCLOSED ARC LIGHT.

DELIVERED BEFORE THE SOCIETE INTERNATIONALE DES ELECTRICIANS, PARIS, FRANCE, JANUARY 20, 1897, BY L. B. MARKS, M. M. E., OF NEW YORK CITY.

The unprecedented industrial utilization of the inclosed arc light in America during the past two years has aroused the attention, not only of American electricians and engineers, but of scientists the world over. Although some of the earlier inventors in this field achieved a modicum of temporary success, every attempt to introduce the inclosed arc lamp commercially eventually met with decided failure.

Before going into the details of the



VENTILATED ENCLOSED ARC

subject, or presenting a sketch of the art of inclosed arc lighting, it may not be amiss to point out the characteristic distinction between the ordinary arc and the inclosed arc. The ordinary arc, commonly known as the open arc, is generally inclosed in a globe more or less tight at the top and bottom. This is also the case with the inclosed arc. In the former, however, the arc depends for its efficient operation upon an excess of air or oxygen-bearing gas, while in the latter provision is made for the partial or total exclusion of the atmosphere. With this preface, I shall now revert for a few moments to the earlier forms of inclosed arc lamps.

HISTORICAL SKETCH.

The history of the art may be said to date back to 1846, when Mr. Wm. E. Staite first produced an inclosed lamp in which one carbon was supported on a rod passing through an air-tight bushing into a globe, and the other carbon mounted in a tube projecting through the base of the globe and fed by a rack operated by clock-work. In this lamp the arc was struck by pushing the carbons apart by hand.

At that early date Staite pointed out that "the more rarefied or deoxygenated the air around the point of ignition is, the more continuous and brilliant the light; hence may be deduced the propriety of inclosing the electrodes in a vessel of small dimensions, hermetically sealed from the external atmosphere, but with a valve in it for the escape of the included air when the expansion begins to exceed those limits which experience may show to be compatible with the safety of the apparatus."

About a year later Staite improved this lamp in various details. Instead of springing the arc by hand it was done automatically by an electro-magnet. The arc was inclosed in an air-tight globe and the regulation effected by electro-mechanical means.

After Staite's experiment there followed a period of inactivity in this line, and it was not until the 70's that the work was again zealously taken up. In 1878 F. H. Varley brought out a lamp containing an air-tight chamber in which carbon powder was allowed to fall from one electrode to another, as from an hour-glass, the carbon being heated to incandescence in transit. The mechanism of the lamp was so arranged that the carbon, after falling through the arc space and becoming incandescent, was again returned by suitable carriers to go through the same operation. In 1879 George G. André devised an electric lamp in which the carbons were inclosed air-tight in a large globe, no provision having been made for egress or ingress of gases. The oxygen of air in the globe gradually combined with the volatilized carbon, when the lamp was in operation, until finally the electrodes burned in an atmosphere consisting largely of carbon gas.

About this time there was considerable activity in the production of inclosed arcs of a different type; viz., the semi-incandescent arcs. In this form the carbons or other electrodes, as the case may be, are in imperfect contact, the point of juncture being heated to a state of incandescence when the current is passed. Such was the lamp of Brougham, in which the carbons were inclosed in a receptacle from which the atmosphere was excluded; no arc was sprung in this lamp, the light emanating from the incandescent points. Following closely on this, in the year 1880, André and Easton produced a lamp similar to the older type already described, but differing from the latter in that the movable carbon was maintained in contact with the negative in a closed chamber, and was fed upward as the carbons burned away, the feed being effected by a weight released by a magnet acting on a friction disk. The same type of lamp is also described by Hedges, who substituted a metal disk for the negative carbon, the positive carbon feeding and continuously bearing against this metal disk, and heating the joint to incandescence.

The well known lamp of Werdermann, which was brought out in 1882, is another type of the typical

incandescent arc. In Werdermann's lamp the carbons were inclosed in an air-tight globe. A thin carbon pencil was propelled against a large negative electrode by a spring; the pencil passed through a block of magnesium or other refractory substance, and a considerable length of the electrode between the block and the contact was rendered incandescent. After the lamp was started the oxygen contained in the globe quickly combined with the carbon, the residual gases thus consisting of nitrogen and carbonic oxides. Among other lamps of the same type, in which no true arc was sprung, were the earlier forms of Jansen in 1875 and Scott in 1878, and subsequently those of Rapieff, Nordenfeldt, Pilleux and Quesnot.

The record of development between 1880 and 1884 shows that a number of lamps of the inclosed type, in which a true arc was sprung, were produced. The principal ones were that of Varley, in which the arc was inclosed in a glass globe or shade filled with carbonic anhydride, or hydrogen, or dried nitrogen; those of Wallace, Brewer and Menges; that of Beardslee, in which the arc was inclosed in a small globe, air-tight at the bottom and having a contracted neck at the top through which the movable carbon passed; that of Baxter, in which the entire lamp mechanism was inclosed air-tight, provision for the egress of heated gases under pressure being made by suitable valves connecting the inclosure with the outer air; and that of Short, similar to the last. Besides these there were several others, differing from those cited only in detail.

THE INCLOSED ARC IN AMERICA.

In America the first attempts to utilize the inclosed arc in commerce date back to the early eighties, when Beardslee produced an inclosed arc and William Baxter experimented with long-hour inclosed lamps. Baxter's experiments and tests covered a period of years, but resulted in failure. From time to time other inventors took up the subject, but as the ground covered by them differs very little from that of earlier efforts, it will not be necessary to dilate here upon the various schemes attempted since the original presentation of the Beardslee and Baxter lamps, respectively. This brings us to the time when Howard took up this line of work in conjunction with me about five years ago. Most of you are familiar with the tests reported by me at the International Electrical Congress, at Chicago, in August, 1893. This paper was hastily prepared to present a subject which, in the opinion of those who had witnessed the trials, was deemed worthy of the fullest description possible at the time. The arrangement of parts disclosed in the lamp referred to in the paper at Chicago was rather unique in some details, but in principle did not differ essentially from earlier forms. It was thought at that time that the inclosed arc would have a large field on constant-current circuits, and an attempt was made to equip existing lamps with the inclosing device. This device, which was very crude, consisted of a cylindrical glass receptacle clamped by disks, which pressed tightly against its upper and lower edges, respectively, the lower end being closed air-tight and the upper end provided with an opening through which the positive carbon passed. In this equipment the negative electrode was made of metal. I shall have occasion to allude to this metal negative later on; also to point out the prime cause of failure in this, as well as in many of the other forms of inclosed arc herein referred to. Subsequently, another device was used, which consisted simply of a small bulb, fitted practically air-tight at the bottom and closed on top by a valved cap through which the upper carbon fed. This appurtenance could be attached to any arc lamp. The negative electrode was in this case made of carbon. A circuit of lamps of this type was tested in the Winter of 1893 and early part of 1894, at Buffalo, N. Y. The report and discussion of tests were published in the electrical journals of the time; also in the transactions of the National Electric Light Association, Washington, D. C., convention, 1894.

We come now to the ventilated inclosed arc, which was devised by me a few years ago and described in some of your technical journals. You will note from the cut presented herewith that the inclosure is provided with means for directing the path of the ingress of air and the egress of gas. You observe that the bulb is pressed tightly against a practically air-tight bottom and is closed at the upper end by a bell-shaped cap or plug, wherein resides the novelty of the equipment. This plug is made of metal and is shaped so that the rim is brought closely adjacent to the exterior wall of the envelope, thus providing a narrow annular passage for the outside air into the envelope, by means of which the entering air is highly heated in transit before reaching the interior of the bulb. You will also see that the tubular opening through which the upper carbon feeds is conical in shape, the opening at the top being only a little greater than the diameter of the electrode, so as to permit a free feed of the latter and afford an obstructed egress for the gases from the envelope. As the closure touches the glass only at four points, shown in the drawing, the tendency of this arrangement is for all egress to take place by way of the central tubular opening, and of ingress by way of the bell-shaped chamber. In other words, the convection currents naturally formed by the heat of the arc are taken advantage of to secure a steady and uniform circulation of oxygen bearing gas in the inclosure. By the use of this equipment the life of the electrodes was prolonged three or four times, the lamps being operated on a constant-current circuit under practically the same conditions as to current and voltage as the open arcs. In practice it was found that the ventilated inclosed arc had many shortcomings, and could rarely be operated under favorable conditions on commercial circuits.

(To be continued.)

The First Radiograph Showing Arterial Circulation, Made in Hudson Street Hospital, New York.

Superintendent Herman A. Knoll and Dr. Philip E. Johnson, both of the Hudson Street Hospital, New York, have recently accomplished important advances in the use of X rays in connection with surgery, inasmuch as they have been able to make a negative showing clearly defined the arterial circulation of the forearm. Up to this time, we believe, the control of the X rays has not permitted the showing or indication of the blood circulation.

RADIOGRAPH SHOWING BRACHIAL ARTERY WITH LIME DEPOSITS IN BLOOD.

The illustration shown herewith is made directly from a print of the negative. In the half-tone processes it is not possible to retain the same delicacy and accuracy of shadows or tones that appear in the print of the negative, and in this reproduction the very slightest touch of the engraver's brush has been given to the arteries to make it equal in strength to the negative print, but it is in no degree an exaggeration of the photograph kindly furnished the ELECTRICAL REVIEW by Superintendent Knoll.

The engraving shows the brachial artery and its bifurcation at or near the elbow into the radial and ulnar arteries.

The exposure, Superintendent Knoll stated, was less than one minute—about 50 seconds—and the apparatus used was that known as the "Edison."

The theory has been advanced that the subject from which this radiograph was made might have had an unusual supply of lime salts in the blood, and in this case it might have had the effect of bringing out in greater relief the arteries when the picture was made.

TELEPHONE NEWS AND COMMENT.

The reported gross earnings for the year of the Chicago Telephone Company were $1,955,829; net, $600,205, or 13.84 per cent on the stock.

The American Electric Telephone Company, of Kokomo, Indiana, has now over 300 exchanges and 50,000 telephones in operation in all parts of the United States.

The Erie Telegraph and Telephone Company made a net gain of 273 subscribers in December, and 2,798 for the year 1896. Total number connected January 1, 21,389.

The annual report of the Central Union Telephone Company shows that the gross earnings for the year were $1,327,931; expenses, $1,026,-311; net earnings after interest charges, $237,099.

A bill was introduced in the New York State Assembly on January 19 regulating telephone charges, so that New York is to pay $85 rental per annum and Brooklyn $75, with proportionate reduction in case of cities with smaller populations.

A plan for a citizens' telephone company is being discussed in Albany. It is estimated that a contribution of $25 each from 500 subscribers would pay for a complete equipment, and that the annual cost of maintenance and operation would not exceed $5 for each telephone.

The Southwestern Telegraph and Telephone Company, of New York city, on January 22 filed with the Secretary of State a certificate of increase of capital stock from $3,000,000 to $4,000,000. The company has a paid-in capital of $3,000,000, and debts and liabilities of $225,000.

At the annual election of the Superior–Duluth, Minn., Telephone Company the following officers were elected: President, A. G. Fuller; vice-president and treasurer, A. W. Taussig; secretary, C. H. Graves; manager, Edward Lomasney. The old directors were all re-elected.

The Sandy River, Me., Telegraph Company, at its annual meeting, elected the following directors: A. M. Greenwood, F. E. Timberlake, Phillips; Chester Greenwood, Farmington; P. H. Stubbs, Strong; W. H. Cook, Farmington. The directors organized and chose A. M. Greenwood, president; F. W. Butler, Farmington, clerk and treasurer.

A Big Electrical Year.

[From the Philadelphia Press]

There has recently been more interest in electr'cal stocks not only in New York, but in this and the Boston markets. No industry in the country has such good prospects for business and immediate profits. All the leading concerns have orders ahead, and the prospect is for a big year.

THE NORTHWESTERN ELECTRICAL ASSOCIATION.

The Fifth Annual Convention Very Successfully Held at Milwaukee.

THE PROCEEDINGS AND PROGRAMME—PAPERS OF VALUE WERE DISCUSSED WITH ANIMATION BY THE PRACTICAL MEN IN ATTENDANCE.

The annual convention of the Northwestern Electrical Association was held at the Hotel Pfister, Milwaukee, Wis., January 20 to 22. Mr. H. C. Higgins, vice-president, called the convention to order in the hotel club-room at 11.40 A. M. A telegram from the president, Mr. W. B. Baker, announced that illness prevented his attendance.

After roll-call and report of secretary, Thos. R. Mercein, a vote of appreciation of the services of the secretary was unanimously adopted.

The programme was announced as follows:

WEDNESDAY.

Convene; roll-call; reading of minutes; president's address; reports of officers; reports of committees; elections to membership; election of officers; unfinished business; new business.

Paper, "Incandescent Lamps," by F. S. Terry, Chicago.

Paper, "Protective Devices for Transformers," by H. C. Wirt, Schenectady, N. Y.

Paper, "Insurance as Affected by Electrical Construction," by George S. McLaren, Milwaukee.

Paper, "Roentgen Ray Phenomena," by Caryl D. Haskins, Boston.

9.30 P. M., Banquet, Hotel Pfister.

THURSDAY.

Convene, 10 A. M.

Paper, "Safety Devices for Electrical Circuits," by Prof. W. M. Stine, Chicago.

Paper, "Gaseous Fuel as a Means of Cheapening Electricity," by Nelson W. Perry, New York.

Paper, "Electrical Supplies," by W. W. Low, Chicago.

Paper, "Electric Heating," by George Cutter, Chicago.

7.30 P. M., Theatre Party, Uihlein Theatre.

FRIDAY.

Convene, 10 A. M.—Closing session. Balance of day devoted to visiting electric plants, etc.

The secretary then read 28 applications for membership in the association, all of which were elected to membership.

On motion, a committee, consisting of Messrs. Debell, Copeland and Hawley, were appointed to arrange for proper remuneration for the secretary, whose excellent work was highly complimented.

Mr. F. S. Terry's paper was then read. This paper and others, with the discussion, will be published in the ELECTRICAL REVIEW in later issues.

AFTERNOON SESSION.

At 3.50 P. M. the election of two new members, the Chas. E. Gregory Company and the Electrical Exchange, of Chicago, occurred.

Mr. H. C. Wirt's paper followed, and after its discussion, was followed by the paper by Mr. Geo. S. McLaren, who received a vote of thanks. The paper was discussed at considerable length.

An amendment to the by-laws, dropping from the roll of members those in arrears one year for dues, was presented by Mr. Kountz.

It was voted that the statistics referred to by the secretary in his report as being obtained from the various central stations, be printed in pamphlet form and a copy sent gratis to each central station that has furnished the information and to each member of the association, without names, but with a key.

Mr. Hanley: I move that the secretary defer printing the report for 30 days, and that he in the meantime notify such members of the association as have not answered the questions heretofore referred to what the intention of the association is, and to ask them to furnish such information. Carried.

Mr. Doherty, of the special committee on municipal ownership, then made his report. It was followed with discussion by Messrs. Coleman, Buckley and Bean. The report was then adopted and referred to the executive committee, with authority to furnish means for the committee to carry on its work.

Mr. Debell: The committee on secretary's salary begs leave to report that it recommends that the salary of the secretary for the ensuing year be fixed at $150, and that $50 in addition to that amount be allowed as extra compensation for the last year's work.

We deem that $150 really is not as much as the work is worth, but we think for the coming year it is as much as the association can well afford, and we think the work done in the past year deserves a great deal more compensation than has been allowed for it up to the present time, and that is why we recommend that $50 be allowed for the past year's work, and that the salary for the coming year be $150.

Report unanimously adopted.

The association then adjourned to meet January 21, 1897, 10 A. M.

In the evening a lecture on X-ray phenomena was delivered by Mr. Caryl D. Haskins.

On Thursday, after listening to an address by Mr. Pierce on "Municipal Lighting," and by Mr. Schuette on a similar subject, the convention elected the following officers for the ensuing year: President, H. C. Higgins, of Marinette; first vice-president, G. L. Cole, of Beloit; John H. Harding, of La Porte, Ind.; secretary and treasurer, Thos. R. Mercein, of Milwaukee; board of directors: Messrs. Debell, of Sheboygan; Rau, of Milwaukee, and Bean, of St. Joseph, Mich.

The reading of Professor Stine's paper followed.

On motion of Mr. Schuette, it was voted to authorize the Protective Committee to engage some one to watch State legislation, and assess the costs on the plants in the jurisdiction of the association.

The amendment to the by-laws heretofore proposed by Mr. Kountz was then unanimously adopted.

Five applicants for membership were acted upon favorably, and the applicants declared duly elected members of the association.

La Crosse, Wis., was selected, after considerable discussion, as the next place of meeting.

Mr. W. W. Low, of Chicago, then read his paper on "Electrical Supplies." The association extended him a vote of thanks. Mr. N. W. Perry's paper was read by the secretary. Mr. Cutter's paper followed.

Adjourned *sine die*.

The American Association of Inventors.

The regular annual meeting of the American Association of Inventors and Manufacturers was held in Washington on the 19th instant. Dr. R. J. Gatling and Mr. Gardiner G. Hubbard, who have held the offices of president and first vice-president, respectively, since the organization of the association, five years ago, and under whose auspices it has been made so successful and useful, expressed a desire to be relieved from further service, and a change in the official board was therefore made. The newly elected officers are: President, F. H. Richards, Hartford, Ct.; first vice-president, J. C. Anderson, Chicago, Ill.; second vice-president, L. W. Serrell, New York city; third vice-president, Philip T. Dodge, New York city; fourth vice-president, M. C. Stone, Washington, D. C.; secretary and treasurer, Geo. C. Maynard, Washington, D. C. Members of the executive council: C. E. Billings, Hartford, Ct.; A. S. Bushnell, Springfield, Ohio; Robert S. Taylor, Fort Wayne, Ind.; Albert A. Pope, Boston, Mass.; Arthur Steuart, Baltimore, Md.; Marvin C. Stone, Washington, D. C.; James T. Du Bois, Washington, D. C.; G. H. Schulte, Milwaukee, Wis.; Lewis Miller, Akron, Ohio.

During the several sessions much important business was transacted, and papers relating to the patent interests were read and discussed. Several subjects of special importance to electrical inventors and manufacturers were considered.

The following resolutions embody the views of the association on some of these points:

Whereas, In carrying on the business of the Patent Office in the manner required by law, reference has to be made continuously to over 600,000 specifications and drawings of patents granted in this country, in addition to about the same number of patents granted in foreign countries, and to 50,000 or 60,000 books of reference; and,

Whereas, The accommodations of the Patent Office have for years been utterly inadequate for its necessary work, and the numerous appeals for more room have heretofore been unheeded, notwithstanding the fact that there is over $4,000,000 to the credit of the patent fund; therefore,

Resolved, That this association does most earnestly and emphatically enter its protest against the continuance of this great injustice to the inventors and manufacturers of the country, and urges upon Congress prompt measures for the removal of the Department of the Interior from the Patent Office, and the proper equipment of the building in the most approved manner for the prompt and reliable transaction of the business of the Patent Office; and,

Resolved, That as the Patent Office was originally erected for the use of the bureau, and largely at the expense of the patent fund, we protest against the transfer of the Patent Office to any other building.

Whereas, The United States did, on the 7th day of June, 1887, adhere to the Convention for the Protection of Industrial Property concluded at Paris, March 20, 1883; and,

Whereas, The American Association of Inventors and Manufacturers heartily appreciates and approves the objects and aims of the international convention for the protection of industrial property (inventions, trade-marks and commercial names); and,

Whereas, The convention grants to citizens of the United States the right to publish, use, work or exploit their inventions in any of the nations adhering to the convention during a period of seven months after the date of their applications for patent in this country, and their trade-marks four months; and,

Whereas, The convention also provides that the citizens of any nation a member of the union, whose local law extends equal privileges to the citizens of all other nations members of the union, shall have the right through the State Department of their own governments, to register their trade-marks in the International Bureau established under said convention, and after such registration, to be protected in all of the countries members of the union, as fully as if they had registered in each of the individual nations members of the union; and,

Whereas, Congress has passed no legislation to carry out the terms and spirit of this convention; therefore, it is

Resolved, That it is the earnest desire of this association that the executive and legislative branches of the Government of the United States take such steps as may be necessary to carry out the terms and obligations of the convention, and to secure to the citizens of the United States all of the advantages which may accrue therefrom.

During the past year the association, through its committee on legislation, has given careful attention to proposed amendments to the patent laws which have come before Congress, and its efforts have been largely instrumental in securing the passage of a bill by the House of Representatives, repealing the statute which terminated the life of a United States patent at the same time that the foreign patent having the shortest term expired. Under the present law a patent, although granted for 17 years, is liable to expire at almost any time without the fault of the inventor, due to the fact that he has attempted to patent his invention abroad, and filed his application there before the issue of his United States patent. Under the new bill, which will undoubtedly become a law before the close of the present session of Congress, when an inventor receives a patent it will run the full term of 17 years. The importance of this amendment can not be overestimated.

Among the electrical members of the association are Elihu Thomson, Chas. F. Brush, Thomas D. Lockwood, Henry A. Reed, Leonard F. Requa, Nikola Tesla, Prof. Cyrus F. Brackett, Elias E. Ries, Emile Berliner, A. G. Davis, Harry H. Blades, Herman Hollerith and Charles S. Tainter.

The Crocker-Wheeler Installation in the New Astor Hotel.

The Crocker-Wheeler installation in the new Astor hotel is probably the most perfect electrical ventilating equipment ever erected. Thomas J. Fay and Associates, the New York agents and general exporters, 143 Liberty street, New York, have the execution of the contract.

The motors will be direct-connected to blowers and exhausters, and the installation includes the following: Two 24-horse-power motors, maximum speed, 190 revolutions per minute; one 30-horse-power motor, maximum speed, 140 revolutions per minute; one 32-horse-power motor, maximum speed, 175 revolutions per minute; one 40-horse-power motor, maximum speed, 115 revolutions per minute; one 60-horse-power motor, maximum speed, 175 revolutions per minute; one 90 horse-power motor, maximum speed, 140 revolutions per minute.

The Standard Edison Fluoroscopes and Fluorescence Screens.

From the time that the practical application of the fluoroscope and fluorescence screen was apparent, Messrs. Aylsworth and Jackson devoted much energy, in their laboratories at Orange, New Jersey, to the production of this part of the X-ray apparatus, and the results have been the acceptance by the scientific world of their Edison fluoroscopes and screens as the standard. In line with this work, some important facts as to the nature of fluorescent crystals have been established.

X Rays Detect Adulteration.

A German observer points out, says *The Medical Times*, that by the use of the X ray brick dust can be traced in Cayenne pepper, sand in spices and chalk in flour.

X RAYS, APPARATUS AND METHODS.

ABSTRACT OF PAPER READ BEFORE THE ELECTRICAL SECTION OF THE FRANKLIN INSTITUTE, PHILADELPHIA, DECEMBER 1, 1896, BY ELMER G. WILLYOUNG AND H. LYMAN SAYEN.

That Professor Roentgen's discovery of the X ray has initiated many lines of thought promising to greatly extend our knowledge of physical phenomena, as well as to revise many of our previously accepted views, is generally admitted. That the practical results accruing to humanity by virtue of the applications of this discovery in surgical and medical practice are of even greater promise and value is equally conceded. The writers have been engaged for a number of months past in developing apparatus and methods for practical work with especial reference to the needs of the physician and surgeon. For conciseness we split the matter under discussion into a series of subordinate heads, each of which we shall briefly treat.

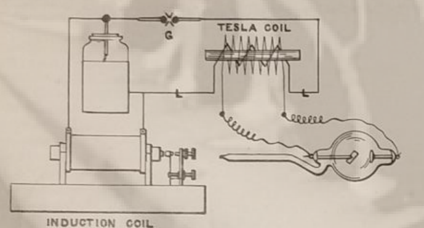


FIG. 1.—"X-RAYS, APPARATUS AND METHODS."—DIAGRAM OF TESLA HIGH-FREQUENCY COIL.

THE COIL OR GENERATING SOURCE.

Thus far the only apparatus known which will produce X rays readily and profusely is the "transformer." Not the commercial transformer of every-day use, however, but its earlier and, for most purposes, less efficient form, the "induction coil." Such a transformer gives exceedingly great electro-motive forces, capable of producing discharge over long air gaps. When the discharge from such a coil is passed through properly exhausted and constructed tubes, we have a very vigorous generation of X rays.

Two arrangements of the induction coil are advocated. The one is known as the Tesla or "high-frequency" coil, and the other is the direct and old-fashioned use of the simple induction coil, in which the high secondary electro-motive force is delivered direct to the terminals of the tube.

THE HIGH-FREQUENCY COIL

consists of two induction coils, the induced secondary current of the first being used to charge a Leyden jar. The primary of the second coil is joined, in series with a spark gap, to the two coatings of the Leyden jar. When the Leyden jars are fully charged they discharge across the air gap, this discharge being, by well known laws of electrical circuit flow, an oscillating one of exceedingly high frequency—millions or more oscillations per second. We thus have the primary of the second coil excited by an alternating current of exceedingly great voltage and frequency, so that *its* secondary produces a discharge of still *greater* electro-motive force and of this same high frequency. So great is this final electro-motive force that it is generally necessary to immerse the entire second coil, primary and all, in a tank of oil, since no solid insulation has yet been found capable of standing these great electro-motive forces without breakdown.

To excite the Tesla coil we may use either an interrupted direct current or an ordinary alternating circuit joined directly to the primary of the first coil. But the final result is, in either case, an alternating, high-potential, high-frequency current. In the tube, therefore, we also have an alternating discharge.

THE INDUCTION COIL.

The primary must be excited by an interrupted direct current, which may be supplied by primary batteries, storage batteries, or a commercial circuit, as convenience and inclination may elect. The secondary is joined directly to the tube terminals. Around the primary is joined a condenser. At break this condenser charges (thus preventing the extra induced current due to the large self-induction of the primary), but, being "short circuited" by the primary, at once discharges about the iron core in a direction opposite to the regular "make" current, thus reducing (if correctly proportioned) the magnetic intensity of the iron core to zero. All this takes place so quickly that the practical effect of the action is merely to assist and intensify the dropping off of the core's magnetism—to shove it along—hasten it. Considering the secondary, now, we find that we shall have at *break* an induced discharge of greatly higher electro-motive force than the discharge at *make*, owing to the falling off of the core's magnetism *at* break being greatly sharper than its growth at make. The effect of this is to give secondary discharges in *one direction only* at all times when the parallel spark gap is not *greatly* shorter than the *maximum* obtainable spark gap for that particular condition of running the coil, the *make* induced current at such times being of too small electro-motive force to get across the gap at all. This is always the condition when X-ray tubes are used. A further function of the condenser is to suppress *burning* at the "break" terminals or points of interruption by taking up the energy of the magnetic discharge of the coil.

In the construction of the induction coil a number of points may be noted. Our secondaries are wound in sections one-eighth-inch thick (according to the plan originally proposed, we believe, by Ritchie). These sections are separated from one another by a large number of disks of paper of a brand especially selected as free from carbon particles and baked at a temperature a little below charring point for some time immediately before use—this to drive out moisture. These sections are then assembled and immediately immersed in a special insulation composition having a very high melting point and some slight viscosity at all temperatures. Paraffine we absolutely prohibit, as being apt to crack and absorb moisture. After cooking for some time in the insulation, so as to drive out the last traces of moisture, the stack of sections is subjected to a further treatment, by which it is finally cooled, with *all air removed*. This we consider a point of the highest importance, as air present anywhere in the secondary becomes electrified and bombards to and fro, gradually softening the insulation and eventually breaking down the coil. (See Tesla's writings on "High-Frequency Phenomena" for confirmation of this point.) With this plan of construction we have no static leaks of energy or small direct leaks within the coil itself, and deliver the full energy of discharge at the secondary terminals.

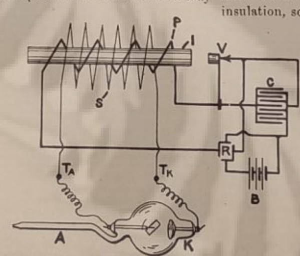


FIG. 2.—"X-RAYS, APPARATUS AND METHODS."—CONNECTIONS OF SIMPLE INDUCTION COIL.

We find ourselves able to secure in this way a full inch of spark, in all sizes of coils, with considerably less than one pound of wire, No. 34 Brown & Sharpe. We believe that, more than anything else, the large quantities of wire required to produce a given spark length with many of the coils now in use is due to the presence of air and consequent loss of energy by static bombardment in the secondary. As regards the insulating composition used by us, we may say that we find its power of resistance to spark discharge to be four or five times that of hard rubber. In the arrangement of our secondary we separate it from the primary by a heavy hard-rubber tube and, in addition, by a tube of this composition.

THE ADJUSTABLE CONDENSER.

A coil is working to best advantage when there is a certain definite relation between its primary current, secondary spark distance and condenser capacity. Frequency of break must also be considered. As coils have heretofore been built, however, the condenser value has been fixed once for all and admits of no change, albeit both spark gap and primary current, and primary current may be so changed. To remedy this we have devised a form of switch, by means of which the condenser capacity may be shifted at will and instantly by simply turning the switch. The effect upon the secondary discharge is very marked, both volume and musical note of the spark changing with the position of the switch. We have made some experiments in the use of a condenser in the parallel *with the primary*. The volume of the secondary discharge seems, in many cases, to be greatly increased. We find this idea exceedingly convenient in general experimental work with alternating currents; indeed, it being possible with it to alter condenser capacity as quickly and as readily as we may self-induction or resistance.

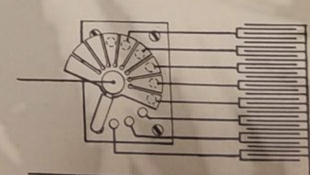


FIG. 3.—"X-RAYS, APPARATUS AND METHODS."—THE AUTHORS' FORM OF SWITCH.

In arranging coils to operate from few or many cells of battery, it is, of course, merely a matter of winding the primary of coarse or fine wire, the number of ampere turns being kept the same. It is interesting to note, as we have noted experimentally many times, that the larger the primary electro-motive force the smaller must be the condenser capacity employed, and *vice versa*. This is, of course, only to be expected, since capacity and self-induction are inverse functions of one another.

PRIMARY CURRENT.

This may be either from primary batteries, storage batteries, or from a

commercial direct-current circuit. Primary batteries have too high resistance to give sufficient current for coils of much size—say four-inch and over—unless joined in parallel, and then we need a number of such groups to secure the requisite electro-motive force. They are a nuisance to attend to, soon run down and are expensive to operate. Storage batteries are exceedingly satisfactory, are comparatively inexpensive to operate and require practically no attention. Charging them is more or less of a nuisance, however, especially where they must be sent out of the building, as they usually must, besides throwing the entire apparatus out of use while charging is going on, unless one have a reserve set of batteries.

The utilization of a direct commercial circuit, such as the Edison 110-volt E. G., where such is available, is in every way the most convenient and satisfactory. Until Professor Roentgen's discovery, no method of

Fig. 4.—"X Rays, Apparatus and Methods."—The Authors' Device for Operating Coils on Commercial Circuits.

operating large coils upon such a circuit had been developed. Recently, however, several methods have been brought out, notably that of the "air break" with air blast to blow out the spark, as used by Dr. Wm. J. Morton, Dr. M. I. Pupin and others. We have devised a form of apparatus to accomplish this purpose. A Lundell one-twelfth-horse-power motor is supported upon a base with its shaft vertical. A casting attached to the motor supports above the latter a copper can made up of two concentric cylinders joined by a ring below, so that the shaft passes up through the inner cylinder and thus avoids the necessity of a stuffing box. From the shaft is hung, well within the can, a heavy brass wheel having stretches of insulating slate let into its periphery. A hard-rubber lid fits over the top of the can. Mounted upon this lid are two brushes, one bearing against the wheel periphery and the one against the shaft; suitable springs and screws allow the brush tension to be varied. From the commercial circuit leads are brought to these two brushes, the current being first passed through the primary of the coil and a rheostat in series. Before the lid is put in place, the can is filled with distilled water; ordinary hydrant water will answer, although its usual impurity causes the water to soon dirty, besides allowing a certain amount of electrolysis during use. With distilled water the break may be run for a number of hours without change of the water, and very little heating takes place. The real function of the water is not so much to drown the spark as to prevent heating, although it does, of course, also assist in quenching the spark. But a condenser is the real spark extinguisher, and this we connect around the break just as we would around an ordinary vibrating break.

The advantages of this break over all forms of vibrating break thus far known and over other forms of rotary break are:

A. Convenience: Mere throwing of a switch being all that is required to start and stop the apparatus.

B. Noiselessness: Only the drowsy hum of the motor being heard.

C. Reliability: No chance of sticking, as with vibrating breaks.

D. Variable rate of break, secured by adjusting rheostat in base of motor.

E. Smooth, unvarying fluoroscopic images, owing to the much larger number of breaks per unit of time.

Two milled heads at top of can permit its lid (carrying brushes) to be withdrawn. A similar head at top of shaft loosens break-wheel, and two heads at bottom of can allow it to be lifted away for cleaning and renewal and replenishing of water.

We use three makes and three breaks per revolution and find best results at from 1,200 to 1,400 revolutions per minute (equal to 3,600 to 4,800 interruptions). We may secure as many as 2,000 revolutions (6,000 interruptions) per minute by cutting out the motor regulator.

In operation, the brush bearing upon break-wheel should be *positive*, so as to prevent any electrolysis of the break-wheel. We have often broken between 15 and 20 amperes through this wheel for a considerable length of time without any overheating or overwear of the wheel. Should the wheel wear in time to an undesirable degree, it may be removed and turned down. Provision is also made for replacing the brushes when desired.

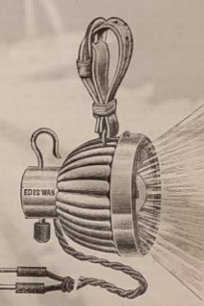
GENERAL CONSIDERATIONS REGARDING BREAK FREQUENCY.

The question as to whether there is a certain best frequency of break for a given coil or tube, or both, has puzzled not a few. Very little has been experimentally determined regarding this point. It is certain, however, that, with a given coil or tube, shortness of exposure is *not* exactly inversely as the number of breaks. Indeed, it is often far from being so. Some of the best X-ray pictures that have been taken have been by use of the old "hammer" break of Ritchie, and four or five clicks of the break have sufficed. Using the same tube and coil, but a rapidly vibrating or rotary break, required 40 or 50 breaks to accomplish the same results. It would appear, hence, that the energy of X-ray radiation *per break* is a function of the number of breaks per unit of time.

We are inclined to believe that this is a matter purely of the "time constant" of the coil. The iron of the core requires a certain time to magnetize or demagnetize. With the breaks few, ample time is given for this process; but when the breaks become rapid this is no longer possible, so that the secondary electro-motive force falls. This may easily be verified by observing the maximum spark length of any coil. With single breaks few and far between, we get much longer spark maxima than if the breaks are frequent. The thickness of the sparks is also greatly increased. If, however, we increase the primary electro-motive force for the more rapid break, we may bring up the secondary spark length to the value given by the single breaks. We should thus be able to shorten the exposure as much as we please by merely increasing the rate of break and the primary electro-motive force at the same time. But here we are limited by the *tube*, which can not *dissipate* more than a certain definite amount of energy in a given time, and will break down if overdriven. We see, therefore, that, whether we use slow breaks or fast breaks, the actual time of exposure remains practically the same, the few breaks requiring to be distributed over the same *time* as the much larger number of rapid breaks. All this, of course, applies to the photographic plate. For fluoroscopy we require rapid breaks, in order to escape the otherwise distressing flickering.

In the above connection particular attention is directed to one point—the rate of break *must not be too great*. If it is, the iron no longer has time to magnetize and demagnetize. The result is an *alternating* secondary discharge instead of the *direct* discharge desired, and this means blackening of the tube, rapid fluctuations of the vacuum and general deterioration of the tube. *We doubt whether with any coil of size suitable for X-ray work a rate of break greater than 5,000 per minute should ever be employed.*

[To be concluded.]



The "Cat-Eye" Electric Bicycle Lamp.

Dr. Fleming's Lecture on the X Ray.

In concluding his course of lectures at the London Institution, Prof. J. A. Fleming described the wonders of the X rays. As reported in the *World of Science*, he explained the part which Mr. Crookes had had in the discovery, and experimented with some high-vacuum tubes. When electricity was applied to these tubes the rays of light shooting off from a negative pole struck against the walls of the tube with such force as to make it vibrate, and a green light was produced inside the tube. Rays of light were also produced outside the tube. These were the wonderful X rays, and though they were strong enough to see through wood, leather and many other substances, they could not be seen by the eye.

It was, Professor Fleming thought, quite as well that the eye did not utilize these rays, for we should probably see more than our neighbors would approve of. It would, for instance, be no use to say you were out to a visitor if you were not, as he would be able to see through wooden doors as easily as he now could see through a window. Already this discovery had been a great aid to surgery, and although it was not much more than a year old, such progress had been made that with the rays one could now look inside a man and see his heart beating. Doctors would, he thought, soon be able to see the whole of the interior of human beings.

Pictures of opaque substances photographed through blocks of wood and other covers were exhibited on a lantern screen, not the least interesting being the bones of a mummy 4,000 years old. They were beautiful pictures, showing with great distinctness every bone and every joint. These were taken with the X rays through all the coverings which are required to preserve a 4,000-year-old mummy from contact with the air. The visitors were also shown how they could examine their own bones without the aid of photography, merely using a prepared screen and the X rays.

The "Cat-Eye" Electric Bicycle Lamp.

The Ediswan Company, of London, are the manufacturers of the "cat-eye" electric bicycle lamp, which is illustrated herewith and which was recently described in London *Lightning*. The lamp is provided with a strap and buckle, and also with a hook attachment. It can be either suspended from a button-hole or attached to a bar, or rail, or bracket, or ledge of any kind. The lamp has a powerful lens, and gives amply sufficient light for purposes of reading or examination. The illustration shows the lamp with a strap at the top for fastening it to any convenient place, with a hook for attaching it to the button-hole and with flexible wires for making connections with the battery. There is also furnished an attachment for cycles, into which the lamp will fit. The lamp is driven by a small storage battery. The weight of the complete set is two and one half pounds and the duration of the charge from eight to ten hours.

TESLA ON ELECTRICITY.

HIS ADDRESS IN FULL ON THE OCCASION OF THE COMMEMORATION OF THE INTRODUCTION OF NIAGARA FALLS POWER IN BUFFALO AT THE ELLICOTT CLUB, JANUARY 12, 1897.

I have scarcely had courage enough to address an audience on a few unavoidable occasions, and the experience of this evening, even as disconnected from the cause of our meeting, is quite novel to me. Although in those few instances, of which I have retained agreeable memory, my words have met with a generous reception, I never deceived myself, and knew quite well that my success was not due to any excellency in the rhetorical or demonstrative art. Nevertheless, my sense of duty to respond to the request with which I was honored a few days ago was strong enough to overcome my very grave apprehensions in regard to my ability of doing justice to the topic assigned to me. It is true, at times—even now, as I speak—my mind feels full of the subject, but I know that, as soon as I shall attempt expression, the fugitive conceptions will vanish, and I shall experience certain well known sensations of abandonment, chill and silence. I can see already your disappointed countenances and can read in them the painful regret of the mistake in your choice.

These remarks, gentlemen, are not made with the selfish desire of winning your kindness and indulgence on my shortcomings, but with the honest intention of offering you an apology for your disappointment. Nor are they made—as you might be disposed to think—in that playful spirit which, to the enjoyment of the listeners, is often displayed by belated speakers. On the contrary, I am deeply earnest in my wish that I were capable of having the fire of eloquence kindled in me, that I might dwell in adequate terms on this fascinating science of electricity, on the marvelous development which electrical annals have recorded and which, as one of the speakers justly remarked, stamp this age as the Electrical Age, and particularly on the great event we are commemorating this day. Unfortunately, this my desire must remain unfulfilled, but I am hopeful that in my formless and incomplete statements, among the few ideas and facts I shall mention there may be something of interest and usefulness, something befitting this unique occasion.

Gentlemen, there are a number of features clearly discernible in, and characteristic of, human intellectual progress in more recent times—features which afford great comfort to the minds of all those who have really at heart the advancement and welfare of mankind.

First of all, the inquiry, by the aid of the microscope and electrical instruments of precision, into the nature of our organs and senses, and particularly of those through which we commune directly with the outside world and through which knowledge is conveyed to our minds, has revealed their exact construction and mode of action, which is in conformity with simple and well established physical principles and laws. Hence the observations we make and the facts we ascertain by their help are *real* facts and observations, and our knowledge is *true* knowledge. To illustrate: Our knowledge of form, for instance, is dependent upon the positive fact that light propagates in straight lines, and, owing to this, the image formed by a lens is exactly similar to the object seen. Indeed, my thoughts in such fields and directions have led me to the conclusion that most all human knowledge is based on this simple truth, since practically every idea or conception—and therefore all knowledge—presupposes visual impressions. But if light would not propagate in accordance with the law mentioned, but in conformity with any other law which we might presently conceive, whereby not only the image might not bear any likeness to the object seen, but even the images of the same object at different times or distances might not resemble each other, then our knowledge of form would be very defective, for then we might see, for example, a three-cornered figure as a six or twelve-cornered one. With the clear understanding of the mechanism and mode of action of our organs, we remove all doubts as to the *reality* and *truth* of the impressions received from the outside, and thus we bar out—forever, we may hope—that unhealthy speculation and skepticism into which formerly even strong minds were apt to fall.

Let me tell you of another comforting feature. The progress in a measured time is nowadays more rapid and greater than it ever was before. This is quite in accordance with the fundamental law of motion, which commands acceleration and increase of momentum or accumulation of energy under the action of a continuously acting force and tendency, and is the more true as every advance weakens the elements tending to produce friction and retardation. For, after all, what *is* progress, or—more correctly—development, or evolution, if not a movement, infinitely complex and often unscrutinizable, it is true, but nevertheless exactly determined in quantity as well as in quality of motion by the physical conditions and laws governing? This feature of more recent development is best shown in the rapid merging together of the various arts and sciences by the obliteration of the hard and fast lines of separation, of borders, some of which only a few years ago seemed unsurpassable, and which, like veritable Chinese walls, surrounded every department of inquiry and barred progress. A sense of connectedness of the various apparently widely different forces and phenomena we observe is taking possession of our minds, a sense of deeper understanding of nature as a whole, which, though not yet quite clear and defined, is keen enough to inspire us with the confidence of vast realizations in the near future.

But these features chiefly interest the scientific man, the thinker and reasoner. There is another feature which affords us still more satisfaction and enjoyment, and which is of still more universal interest, chiefly because of its bearing upon the welfare of mankind. Gentlemen, there is an influence which is getting strong and stronger day by day, which shows itself more and more in all departments of human activity, an influence most fruitful and beneficial—the influence of the artist. It was a happy day for the mass of humanity when the artist felt the desire of becoming a physician, an electrician, an engineer or mechanician or—whatnot—a mathematician or a financier; for it was he who wrought all these wonders and grandeur we are witnessing. It was he who abolished that small, pedantic, narrow-grooved school teaching which made of an aspiring student a galley-slave, and he who allowed freedom in the choice of subject of study according to one's pleasure and inclination, and so facilitated development.

Some, who delight in the exercise of the powers of criticism, call this an assymetrical development, a degeneration or departure from the normal, or even a degradation of the race. But they are mistaken. This is a welcome state of things, a blessing, a wise subdivision of labors, the establishment of conditions most favorable to progress. Let one concentrate all his energies in one single great effort, let him perceive a single truth, even though he be consumed by the sacred fire, then millions of less gifted men can easily follow. Therefore it is not as much quantity as quality of work which determines the magnitude of the progress.

It was the artist, too, who awakened that broad philanthropic spirit which, even in old ages, shone in the teachings of noble reformers and philosophers, that spirit which makes men in all departments and positions work not as much for any material benefit or compensation—though reason may command this also—but chiefly for the sake of success, for the pleasure there is in achieving it and for the good they might be able to do thereby to their fellow-men. Through his influence types of men are now pressing forward, impelled by a deep love for their study, men who are doing wonders in their respective branches, whose chief aim and enjoyment is the acquisition and spread of knowledge, men who look far above earthly things, whose banner is Excelsior! Gentlemen, let us honor the artist, let us thank him, let us drink his health!

Now, in all these enjoyable and elevating features which characterize modern intellectual development, electricity, the expansion of the science of electricity, has been a most potent factor. Electrical science has revealed to us the true nature of light, has provided us with innumerable appliances and instruments of precision, and has thereby vastly added to the exactness of our knowledge. Electrical science has disclosed to us the more intimate relation existing between widely different forces and phenomena and has thus led us to a more complete comprehension of Nature and its many manifestations to our senses. Electrical science, too, by its fascination, by its promises of immense realizations, of wonderful possibilities chiefly in humanitarian respects, has attracted the attention and enlisted the energies of the artist; for where is there a field in which his God-given powers would be of greater benefit to his fellow-men than this unexplored, almost virgin, region, where, like in a silent forest, a thousand voices respond to every call?

With these comforting features, with these cheering prospects, we need not look with any feeling of incertitude or apprehension into the future. There are pessimistic men, who, with anxious faces, continuously whisper in your ear that the nations are secretly arming—arming to the teeth; that they are going to pounce upon each other at a given signal and destroy themselves; that they are all trying to outdo that victorious, great, wonderful German army, against which there is no resistance, for every German has the discipline in his very blood—every German is a soldier. But these men are in error. Look only at our recent experience with the British in that Venezuela difficulty. Two other nations might have crashed together, but not the Anglo-Saxons; they are too far ahead. The men who tell you this are ignoring forces which are continually at work, silently but resistlessly—forces which say Peace!

There is the genuine artist, who inspires us with higher and nobler sentiments, and makes us abhor strife and carnage. There is the engineer, who bridges gulfs and chasms, and facilitates contact and equalization of the heterogeneous masses of humanity. There is the mechanic, who comes with his beautiful time and energy-saving appliances, who perfects his flying machine, not to drop a bag of dynamite on a city or vessel, but to facilitate transport and travel. There, again, is the chemist, who opens new resources and makes existence more pleasant and secure; and there is the electrician, who sends his messages of peace to all parts of the globe. The time will not be long in coming when those men who are turning their ingenuity to inventing quick-firing guns, torpedoes and other implements of destruction—all the while assuring you that it is for the love and good of humanity—will find no takers for their odious tools, and will realize that, had they used their inventive talent in other directions, they might have reaped a far better reward than the sestertia received. And then, and none too soon, the cry will be echoed everywhere, Brethren, stop these highhanded methods of the strong, these remnants of barbarism so inimical to progress! Give that valiant warrior opportunities for displaying a more commendable courage than that he shows when, intoxicated with victory, he rushes to the destruction of his fellow-men. Let him toil day and night with a small chance of achieving and yet be unflinching; let him challenge the dangers of exploring the heights of the air and the depths of the sea; let him brave the dread of the plague, the heat of the tropic desert and the ice of the polar region. Turn your energies to warding off the common enemies and dangers, the perils that are all around you, that threaten you in the air you breathe, in the water you drink, in the food you consume. Is it not strange, is it not shame, that we, beings in the highest state of development in this our world, beings with such immense powers of thought and action, we, the masters of the globe, should be absolutely at the mercy of our unseen foes, that we should not know whether a swallow of food or drink brings joy and life or pain and destruction to us! In this most modern and sensible warfare, in which the bacteriologist leads, the services electricity will render will prove invaluable. The economical production of high-frequency currents, which is now an accomplished fact, enables us to generate easily and in large quantities ozone for the disinfection of the water and the air, while certain novel radiations recently discovered give hope of finding effective remedies against ills of microbic origin, which have heretofore withstood all efforts of the physician. But let me turn to a more pleasant theme.

I have referred to the merging together of the various sciences or departments of research, and to a certain perception of intimate connection between the manifold and apparently different forces and phenomena. Already we know, chiefly through the efforts of a bold pioneer, that light, radiant heat, electrical and magnetic actions are closely related, not to say identical. The chemist professes that the effects of combination and separation of bodies he observes are due to electrical forces, and the physician and physiologist will tell you that even life's progress is electrical. Thus electrical science has gained a universal meaning, and with right this age can claim the name "Age of Electricity."

I wish much to tell you on this occasion—I may say I actually burn for desire of telling you—what electricity really *is*, but I have very strong reasons, which my co-workers will best appreciate, to follow a precedent established by a great and venerable philosopher, and I shall not dwell on this purely scientific aspect of electricity.

There is another reason for the claim which I have before stated which is even more potent than the former, and that is the immense development in all electrical branches in more recent years and its influence upon other departments of science and industry. To illustrate this influence I only need to refer to the steam or gas engine. For more than half a century the steam engine has served the innumerable wants of man. The work it was called to perform was of such variety and the conditions in each case were so different that, of necessity, a great many types of engines have resulted. In the vast majority of cases the problem put before the engineer was not, as it should have been, the broad one of converting the greatest possible amount of heat energy into mechanical power, but it was rather the specific problem of obtaining the mechanical power in such form as to be best suitable for general use. As the reciprocating motion of the piston was not convenient for practical purposes, except in very few instances, the piston was connected to a crank, and thus rotating motion was obtained, which was more suitable and preferable, though it involved numerous disadvantages incident to the crude and wasteful means employed. But until quite recently there were at the disposal of the engineer, for the transformation and transmission of the motion of the piston, no better means than rigid mechanical connections. The past few years have brought forcibly to the attention of the builder the electric motor, with its ideal features. Here was a mode of transmitting mechanical motion simpler by far, and also much more economical. Had this mode been perfected earlier, there can be no doubt that, of the many different types of engine, the majority would not exist, for just as soon as an engine was coupled with an electric generator a type was produced capable of almost universal use. From this moment on there was no necessity to endeavor to perfect engines of special designs capable of doing special kinds of work. The engineer's task became now to concentrate all his efforts upon one type, to perfect one kind of engine—the best, the universal, the engine of the immediate future; namely, the one which is best suitable for the generation of electricity. The first efforts in this direction gave a strong impetus to the development of the reciprocating high-speed engine, and also to the turbine, which latter was a type of engine of very limited practical usefulness, but became, to a certain extent, valuable in connection with the electric generator and motor. Still, even the former engine, though improved in many particulars, is not radically changed, and even now has the same objectionable features and limitations. To do away with these as much as possible, a new type of engine is being perfected in which more favorable conditions for economy are maintained, which expands the working fluid with utmost rapidity and loses little heat on the walls, an engine stripped of all usual regulating mechanism—packings, oilers and other appendages—and forming part of an electric generator; and in this type, I may say, I have implicit faith.

The gas or explosive engine has been likewise profoundly affected by the commercial introduction of electric light and power, particularly in quite recent years. The engineer is turning his energies more and more in this direction, being attracted by the prospect of obtaining a higher thermodynamic efficiency. Much larger engines are now being built, the construction is constantly improved, and a novel type of engine, best suitable for the generation of electricity, is being rapidly evolved.

There are many other lines of manufacture and industry in which the influence of electrical development has been even more powerfully felt. So, for instance, the manufacture of a great variety of articles of metal, and especially of chemical products. The welding of metals by electricity, though involving a wasteful process, has, nevertheless, been accepted as a legitimate art, while the manufacture of metal sheet, seamless tubes and the like affords promise of much improvement. We are coming gradually, but surely, to the fusion of bodies and reduction of all kinds of ores—even of iron ores—by the use of electricity, and in each of these departments great realizations are probable. Again, the economical conversion of ordinary currents of supply into high-frequency currents opens up new possibilities, such as the combination of the atmospheric nitrogen and the production of its compounds; for instance, ammonia and nitric acid, and their salts, by novel processes.

The high-frequency currents also bring us to the realization of a more economical system of lighting; namely, by means of phosphorescent bulbs or tubes, and enable us to produce with these appliances light of practically any candle-power. Following other developments in purely electrical lines, we have all rejoiced in observing the rapid strides made, which, in quite recent years, have been beyond our most sanguine expectations. To enumerate the many advances recorded is a subject for the reviewer, but I can not pass without mentioning the beautiful discoveries of Lenard and Roentgen, particularly the latter, which have found such a powerful response throughout the scientific world that they have made us forget, for a time, the great achievement of Linde in Germany, who has effected the liquefaction of air on an industrial scale by a process of continuous cooling; the discovery of argon by Lord Rayleigh and Professor Ramsay, and the splendid pioneer work of Professor Dewar in the field of low temperature research. The fact that the United States have contributed a very liberal share to this prodigious progress must afford to all of us great satisfaction. While honoring

the workers in other countries and all those who, by profession or inclination, are devoting themselves to strictly scientific pursuits, we have particular reasons to mention with gratitude the names of those who have so much contributed to this marvelous development of electrical industry in this country. Bell, who, by his admirable invention enabling us to transmit speech to great distances, has profoundly affected our commercial and social relations, and even our very mode of life; Edison, who, had he not done anything else beyond his early work in incandescent lighting, would have proved himself one of the greatest benefactors of the age; Westinghouse, the founder of the commercial alternating system; Brush, the great pioneer of arc lighting; Thomson, who gave us the first practical welding machine, and who, with keen sense, contributed very materially to the development of a number of scientific and industrial branches; Weston, who once led the world in dynamo design, and now leads in the construction of electric instruments; Sprague, who, with rare energy, mastered the problem and insured the success of practical electrical railroading; Acheson, Hall, Willson and others, who are creating new and revolutionizing industries here under our very eyes at Niagara. Nor is the work of these gifted men nearly finished at this hour. Much more is still to come, for, fortunately, most of them are still full of enthusiasm and vigor. All of these men and many more are untiringly at work investigating new regions and opening up unsuspected and promising fields. Weekly, if not daily, we learn through the journals of a new advance into some unexplored region, where at every step success beckons friendly, and leads the toiler on to hard and harder tasks.

But among all these many departments of research, these many branches of industry, new and old, which are being rapidly expanded, there is one dominating all others in importance—one which is of the greatest significance for the comfort and welfare, not to say for the existence, of mankind, and that is the electrical transmission of power. And in this most important of all fields, gentlemen, long afterwards, when time will have placed the events in their proper perspective, and assigned men to their deserved places, the great event we are commemorating to-day will stand out as designating a new and glorious epoch in the history of humanity—an epoch grander than that marked by the advent of the steam engine. We have many a monument of past ages; we have the palaces and pyramids, the temples of the Greek and the cathedrals of Christendom. In them is exemplified the power of men, the greatness of nations, the love of art and religious devotion. But that monument at Niagara has something of its own, more in accord with our present thoughts and tendencies. It is a monument worthy of our scientific age, a true monument of enlightenment and of peace. It signifies the subjugation of natural forces to the service of man, the discontinuance of barbarous methods, the relieving of millions from want and suffering. No matter what we attempt to do, no matter to what fields we turn our efforts, we are dependent on power. Our economists may propose more economical systems of administration and utilization of resources, our legislators may make wiser laws and treaties, it matters little; that kind of help can be only temporary. If we want to reduce poverty and misery, if we want to give to every deserving individual what is needed for a safe existence of an intelligent being, we want to provide more machinery, more power. Power is our mainstay, the primary source of our many-sided energies. With sufficient power at our disposal we can satisfy most of our wants and offer a guaranty for safe and comfortable existence to all, except perhaps to those who are the greatest criminals of all—the voluntarily idle.

The development and wealth of a city, the success of a nation, the progress of the whole human race, is regulated by the power available. Think of the victorious march of the British, the like of which history has never recorded. Apart from the qualities of the race, which have been of great moment, they own the conquest of the world to—coal. For with coal they produce their iron; coal furnishes them light and heat; coal drives the wheels of their immense manufacturing establishments, and coal propels their conquering fleets. But the stores are being more and more exhausted, the labor is getting dearer and dearer, and the demand is continuously increasing. It must be clear to every one that soon some new source of power supply must be opened up, or that at least the present methods must be materially improved. A great deal is expected from a more economical utilization of the stored energy of the carbon in a battery; but while the attainment of such a result would be hailed as a great achievement, it would not be as much of an advance towards the ultimate and permanent method of obtaining power as some engineers seem to believe. By reasons both of economy and convenience we are driven to the general adoption of a system of energy supply from central stations, and for such purposes the beauties of the mechanical generation of electricity can not be exaggerated. The advantages of this universally accepted method are certainly so great that the probability of replacing the engine dynamos by batteries is, in my opinion, a remote one, the more so as the high-pressure steam engine and gas engine give promise of a considerably more economical thermodynamic conversion. Even if we had this day such an economical coal battery, its introduction in central stations would by no means be assured, as its use would entail many inconveniences and drawbacks. Very likely the carbon could not be burned in its natural form as in a boiler, but would have to be specially prepared to secure uniformity in the current generation. There would be a great many cells needed to make up the electro-motive force usually required. The process of cleaning and renewal, the handling of nasty fluids and gases and the great space necessary for so many batteries would make it difficult, if not commercially unprofitable, to operate such a plant in a city or densely populated district. Again, if the station be erected in the outskirts, the conversion by rotating transformers or otherwise would be a serious and unavoidable drawback. Furthermore, the regulating appliances and other accessories which would have to be provided would probably make the plant fully as much, if not more, complicated than the present. We might, of course, place the batteries at or near the coal mine, and from there transmit the energy to distant points in the form of high-tension alternating currents obtained from rotating transformers, but even in this most favorable case the process would be a barbarous one, certainly more so than the present, as it would still involve the consumption of material, while at the same time it would restrict the engineer and mechanic in the exercise of their beautiful art. As to the energy supply in small isolated places as dwellings, I have placed my confidence in the development of a light storage battery, involving the use of chemicals manufactured by cheap water power, such as some carbide or oxygen-hydrogen cell.

But we shall not satisfy ourselves simply with improving steam and explosive engines or inventing new batteries; we have something much better to work for, a greater task to fulfill. We have to evolve means for obtaining energy from stores which are forever inexhaustible, to perfect methods which do not imply consumption and waste of any material whatever. Upon this great possibility, which I have long ago recognized, upon this great problem, the practical solution of which means so much for humanity, I have myself concentrated my efforts since a number of years, and a few happy ideas which came to me have inspired me to attempt the most difficult, and given me strength and courage in adversity. Nearly six years ago my confidence had become strong enough to prompt me to an expression of hope in the ultimate solution of this all-dominating problem. I have made progress since, and have passed the stage of mere conviction such as is derived from a diligent study of known facts, conclusions and calculations. I now feel sure that the realization of that idea is not far off. But precisely for this reason I feel impelled to point out here an important fact, which I hope will be remembered. Having examined for a long time the possibilities of the development I refer to, namely, that of the operation of engines on any point of the earth by the energy of the medium, I find that even under the theoretically best conditions such a method of obtaining power can not equal in economy, simplicity and many other features the present method, involving a conversion of the mechanical energy of running water into electrical energy and the transmission of the latter in the form of currents of very high tension to great distances. Provided, therefore, that we can avail ourselves of currents of sufficiently high tension, a waterfall affords us the most advantageous means of getting power from the sun sufficient for all our wants, and this recognition has impressed me strongly with the future importance of the water power, not so much because of its commercial value, though it may be very great, but chiefly because of its bearing upon our safety and welfare. I am glad to say that also in this latter direction my efforts have not been unsuccessful, for I have devised means which will allow us the use in power transmission of electro-motive forces much higher than those practicable with ordinary apparatus. In fact, progress in this field has given me fresh hope that I shall see the fulfillment of one of my fondest dreams; namely, the transmission of power from station to station without the employment of any connecting wire. Still, whatever method of transmission be ultimately adopted, nearness to the source of power will remain an important advantage.

Gentlemen, some of the ideas I have expressed may appear to many of you hardly realizable; nevertheless, they are the result of long-continued thought and work. You would judge them more justly if you would have devoted your life to them, as I have done. With ideas it is like with dizzy heights you climb: At first they cause you discomfort and you are anxious to get down, distrustful of your own powers; but soon the remoteness of the turmoil of life and the inspiring influence of the altitude calm your blood; your step gets firm and sure and you begin to look—for dizzier heights. I have attempted to speak to you on "Electricity," its development and influence, but I fear that I have done it much like a boy who tries to draw a likeness with a few straight lines. But I have endeavored to bring out one feature, to speak to you in one strain which I felt sure would find response in the hearts of all of you, the only one worthy of this occasion—the humanitarian. In the great enterprise at Niagara we see not only a bold engineering and commercial feat, but far more, a giant stride in the right direction as indicated both by exact science and philanthropy. Its success is a signal for the utilization of water powers all over the world, and its influence upon industrial development is incalculable. We must all rejoice in the great achievement and congratulate the intrepid pioneers who have joined their efforts and means to bring it about. It is a pleasure to learn of the friendly attitude of the citizens of Buffalo and of the encouragement given to the enterprise by the Canadian authorities. We shall hope that other cities, like Rochester on this side and Hamilton and Toronto in Canada, will soon follow Buffalo's lead. This fortunate city herself is to be congratulated. With resources now unequaled, with commercial facilities and advantages such as few cities in the world possess, and with the enthusiasm and progressive spirit of its citizens, it is sure to become one of the greatest industrial centers of the globe.

Editors Enjoy a Trolley Ride.

The Republican Editorial Association, of the State of New York, held its annual meeting in this city last week. They devoted the afternoon of Thursday to a trolley ride over Brooklyn in the beautiful parlor trolley cars which President Rossiter, of the Brooklyn Street Railway Company, provided for the occasion. Lunch was served in the cars and it was a very enjoyable as well as novel experience for the visiting editors to be whirled through the city of Brooklyn and suburbs while enjoying an excellent repast. After the ride they visited the Brooklyn Navy Yard, and were later entertained at a banquet at the Union League Club, of Brooklyn, through the courtesy of the president of the association, Hon. William Berri, proprietor of the Brooklyn *Standard Union*. The after-dinner speeches at the banquet were of unusual interest and were made by the following eminent gentlemen: Chauncey M. Depew, Elihu Root, Paul Dana, W. J. Arkell, George H. Daniels, Joseph Howard, Jr., Henry Watterson and Lieut. R. E. Peary, U. S. N.

Another Reason Why the Cable Should Go.

[*From the New York Evening Sun.*]

If you stand on a corner and wave your umbrella at a cable car, and it whirls past you without slowing down, don't blame the gripman until you have looked in the newspapers to see how many were injured. It was probably a runaway. The man in front may have been doing his best.

A Belt Manufacturer Assigns.

The assignment is reported of Edwin A. Burgess, a belt manufacturer in Providence, R. I., who did business under the name of A. Burgess & Son.

PERSONAL.

Mr. F. Laughlin, of the Solar Carbon and Manufacturing Company, Pittsburgh, came to New York city last week and made his headquarters at the Hotel Imperial.

Miss Bessie Orne and Mr. F. S. Burke, general manager of the Crown Woven Wire Brush Company, of Salem, Mass., were married at St. Peter's Church, Salem, on January 14.

Col. S. G. Booker, superintendent of the Phœnix Carbon Manufacturing Company, of St. Louis, spent the past week in New York and Boston. His many friends in these cities gave him a cordial welcome.

The West End Street Railway Company, of Boston, has retained Everett W. Burdett to act as legislative counsel at the State House this Winter. He is also counsel for the Boston Electric Light Company at the State House.

Mr. E. T. Copeland, the well known steam-power engineer and contractor, is the eastern representative of the Ball Engine Company, of Erie, Pa. Mr. Copeland's headquarters are at 39 Cortlandt street, New York.

Mr. E. Ward Wilkins, of the firm of Partrick & Carter Company, the well known Philadelphia manufacturers of electrical house goods and general supplies, has started on an extensive western trip, stopping at many of the principal cities between Chicago and San Francisco.

Mr. D. G. Scott, formerly with the American Electrical Works, is now representing in New York city the Crefeld Electrical Works, of Boston, manufacturers of magnet, office, annunciator, rubber-covered and weatherproof wires. Mr. Scott's offices are at 136 Liberty street, New York city.

Mr. C. H. Lease, son of Mrs. Mary Elizabeth Lease, the widely known lecturer, has purchased an interest in the Rousseau Electric Works, New York, and will enter actively into the electrical industry. The Rousseau company was established in 1870 and will no doubt be benefited by the addition of Mr. Lease to its staff.

A Busy Factory.

The Adams-Bagnall factory at Cleveland is one of the busiest establishments in the country to-day, both in the arc lamp and incandescent lamp departments. The improved arc lamp of this company is meeting with much favor wherever tried, and the increasing orders have filled every foot of factory space with workmen and moving machinery. The manager of this company, Mr. L. H. Rogers, is greatly pleased, as he has every reason to be, over the successful business with which his company has been greeted. Mr. Thomas C. Adams and Mr. E. J. Bagnall are both actively interested with the company, and the excellence of the product is largely due to their careful, skillful supervision.

TESLA ON ELECTRICITY.

HIS ADDRESS IN FULL ON THE OCCASION OF THE COMMEMORATION OF THE INTRODUCTION OF NIAGARA FALLS POWER IN BUFFALO AT THE ELLICOTT CLUB, JANUARY 12, 1897.

I have scarcely had courage enough to address an audience on a few unavoidable occasions, and the experience of this evening, even as disconnected from the cause of our meeting, is quite novel to me. Although in those few instances, of which I have retained agreeable memory, my words have met with a generous reception, I never deceived myself, and knew quite well that my success was not due to any excellency in the rhetorical or demonstrative art. Nevertheless, my sense of duty to respond to the request with which I was honored a few days ago was strong enough to overcome my very grave apprehensions in regard to my ability of doing justice to the topic assigned to me. It is true, at times—even now, as I speak—my mind feels full of the subject, but I know that, as soon as I shall attempt expression, the fugitive conceptions will vanish, and I shall experience certain well known sensations of abandonment, chill and silence. I can see already your disappointed countenances and can read in them the painful regret of the mistake in your choice.

These remarks, gentlemen, are not made with the selfish desire of winning your kindness and indulgence on my shortcomings, but with the honest intention of offering you an apology for your disappointment. Nor are they made—as you might be disposed to think—in that playful spirit which, to the enjoyment of the listeners, is often displayed by belated speakers. On the contrary, I am deeply earnest in my wish that I were capable of having the fire of eloquence kindled in me, that I might dwell in adequate terms on this fascinating science of electricity, on the marvelous development which electrical annals have recorded and which, as one of the speakers justly remarked, stamp this age as the Electrical Age, and particularly on the great event we are commemorating this day. Unfortunately, this my desire must remain unfulfilled, but I am hopeful that in my formless and incomplete statements, among the few ideas and facts I shall mention there may be something of interest and usefulness, something befitting this unique occasion.

Gentlemen, there are a number of features clearly discernible in, and characteristic of, human intellectual progress in more recent times—features which afford great comfort ance with the fundamental law of motion, which commands acceleration and increase of momentum or accumulation of energy under the action of a continuously acting force and tendency, and is the more true as every advance weakens the elements tending to produce friction and retardation. For, after all, what *is* progress, or—more correctly—development, or evolution, if not a movement, infinitely complex and often unscrutinizable, it is true, but nevertheless exactly determined in quantity as well as in quality of motion by the physical conditions and laws governing? This feature of more recent development is best shown in the rapid merging together of the various arts and sciences by the obliteration of the hard and fast lines of separation, of borders, some of which only a few years ago seemed unsurpassable, and which, like veritable Chinese walls, surrounded every department of inquiry and barred progress. A sense of connectedness of the various apparently widely different forces and phenomena we observe is taking possession of our minds, a sense of deeper understanding of nature as a whole, which, though not yet quite clear and defined, is keen enough to inspire us with the confidence of vast realizations in the near future.

But these features chiefly interest the scientific man, the thinker and reasoner. There is another feature which affords us still more satisfaction and enjoyment, and which is of still more universal interest, chiefly because of its bearing upon the welfare of mankind. Gentlemen, there is an influence which is getting strong and stronger day by day, which shows itself more and more in all departments of human activity, an influence most fruitful and beneficial—the influence of the artist. It was a happy day for the mass of humanity when the artist felt the desire of becoming a physician, an electrician, an engineer or mechanician or—whatnot—a mathematician or a financier; for it was he who wrought all these wonders and grandeur we are witnessing. It was he who abolished that small, pedantic, narrow-grooved school teaching which made of an aspiring student a galley-slave, and he who allowed freedom in the choice of subject of study according to one's pleasure and inclination, and so facilitated development.

Some, who delight in the exercise of the powers of criticism, call this an assymetrical development, a degeneration or departure from the normal, or even a degradation of the race. But they are mistaken. This is a welcome state of things, a blessing, a wise subdivision of labors, the establishment of conditions most favorable to progress. Let one concentrate all his energies in one single great effort, let him perceive a single truth, even though he be consumed by the sacred fire, then millions of less gifted men can easily follow. Therefore it is not as much quantity as quality of work which determines the magnitude of the progress.

It was the artist, too, who awakened that broad philanthropic spirit which, even in they are going to pounce upon each other at a given signal and destroy themselves; that they are all trying to outdo that victorious, great, wonderful German army, against which there is no resistance, for every German has the discipline in his very blood—every German is a soldier. But these men are in error. Look only at our recent experience with the British in that Venezuela difficulty. Two other nations might have crashed together, but not the Anglo-Saxons; they are too far ahead. The men who tell you this are ignoring forces which are continually at work, silently but resistlessly—forces which say Peace!

There is the genuine artist, who inspires us with higher and nobler sentiments, and makes us abhor strife and carnage. There is the engineer, who bridges gulfs and chasms, and facilitates contact and equalization of the heterogeneous masses of humanity. There is the mechanic, who comes with his beautiful time and energy-saving appliances, who perfects his flying machine, not to drop a bag of dynamite on a city or vessel, but to facilitate transport and travel. There, again, is the chemist, who opens new resources and makes existence more pleasant and secure; and there is the electrician, who sends his messages of peace to all parts of the globe. The time will not be long in coming when those men who are turning their ingenuity to inventing quick-firing guns, torpedoes and other implements of destruction—all the while assuring you that it is for the love and good of humanity—will find no takers for their odious tools, and will realize that, had they used their inventive talent in other directions, they might have reaped a far better reward than the sestertia received. And then, and none too soon, the cry will be echoed everywhere. Brethren, stop these highhanded methods of the strong, these remnants of barbarism so inimical to progress! Give that valiant warrior opportunities for displaying a more commendable courage than that he shows when, intoxicated with victory, he rushes to the destruction of his fellow-men. Let him toil day and night with a small chance of achieving and yet be unflinching; let him challenge the dangers of exploring the heights of the air and the depths of the sea; let him brave the dread of the plague, the heat of the tropic desert and the ice of the polar region. Turn your energies to warding off the common enemies and dangers, the perils that are all around you, that threaten you in the air you breathe, in the water you drink, in the food you consume. Is it not strange, is it not shame, that we, beings in the highest state of development in this our world, beings with such immense powers of thought and action, we, the masters of the globe, should be absolutely at the mercy of our unseen foes, that we should not know whether a swallow of food or drink brings joy and life or pain and destruction to us! In this most modern and sensible warfare, in which the bacteriologist leads, the services electricity will render will prove invaluable. The economical production of high-frequency currents, which is now an ac-

broad one of converting the greatest possible amount of heat energy into mechanical power, but it was rather the specific problem of obtaining the mechanical power in such form as to be best suitable for general use. As the reciprocating motion of the piston was not convenient for practical purposes, except in very few instances, the piston was connected to a crank, and thus rotating motion was obtained, which was more suitable and preferable, though it involved numerous disadvantages incident to the crude and wasteful means employed. But until quite recently there were at the disposal of the engineer, for the transformation and transmission of the motion of the piston, no better means than rigid mechanical connections. The past few years have brought forcibly to the attention of the builder the electric motor, with its ideal features. Here was a mode of transmitting mechanical motion simpler by far, and also much more economical. Had this mode been perfected earlier, there can be no doubt that, of the many different types of engine, the majority would not exist, for just as soon as an engine was coupled with an electric generator a type was produced capable of almost universal use. From this moment on there was no necessity to endeavor to perfect engines of special designs capable of doing special kinds of work. The engineer's task became now to concentrate all his efforts upon one type, to perfect one kind of engine—the best, the universal, the engine of the immediate future; namely, the one which is best suitable for the generation of electricity. The first efforts in this direction gave a strong impetus to the development of the reciprocating high-speed engine, and also to the turbine, which latter was a type of engine of very limited practical usefulness, but became, to a certain extent, valuable in connection with the electric generator and motor. Still, even the former engine, though improved in many particulars, is not radically changed, and even now has the same objectionable features and limitations. To do away with these as much as possible, a new type of engine is being perfected in which more favorable conditions for economy are maintained, which expands the working fluid with utmost rapidity and loses little heat on the walls, an engine stripped of all usual regulating mechanism—packings, oilers and other appendages—and forming part of an electric generator; and in this type, I may say, I have implicit faith.

The gas or explosive engine has been likewise profoundly affected by the commercial introduction of electric light and power, particularly in quite recent years. The engineer is turning his energies more and more in this direction, being attracted by the prospect of obtaining a higher thermodynamic efficiency. Much larger engines are now being built, the construction is constantly improved, and a novel type of engine, best suitable for the generation of electricity, is being rapidly evolved.

There are many other lines of manufacture and industry in which the influence

with the selfish desire of winning your kindness and indulgence on my shortcomings, but with the honest intention of offering you an apology for your disappointment. Nor are they made—as you might be disposed to think—in that playful spirit which, to the enjoyment of the listeners, is often displayed by belated speakers. On the contrary, I am deeply earnest in my wish that I were capable of having the fire of eloquence kindled in me, that I might dwell in adequate terms on this fascinating science of electricity, on the marvelous development which electrical annals have recorded and which, as one of the speakers justly remarked, stamp this age as the Electrical Age, and particularly on the great event we are commemorating this day. Unfortunately, this my desire must remain unfulfilled, but I am hopeful that in my formless and incomplete statements, among the few ideas and facts I shall mention there may be something of interest and usefulness, something befitting this unique occasion.

Gentlemen, there are a number of features clearly discernible in, and characteristic of, human intellectual progress in more recent times—features which afford great comfort to the minds of all those who have really at heart the advancement and welfare of mankind.

First of all, the inquiry, by the aid of the microscope and electrical instruments of precision, into the nature of our organs and senses, and particularly of those through which we commune directly with the outside world and through which knowledge is conveyed to our minds, has revealed their exact construction and mode of action, which is in conformity with simple and well established physical principles and laws. Hence the observations we make and the facts we ascertain by their help are *real* facts and observations, and our knowledge is *true* knowledge. To illustrate: Our knowledge of form, for instance, is dependent upon the positive fact that light propagates in straight lines, and, owing to this, the image formed by a lens is exactly similar to the object seen. Indeed, my thoughts in such fields and directions have led me to the conclusion that most all human knowledge is based on this simple truth, since practically every idea or conception—and therefore all knowledge—presupposes visual impressions. But if light would not propagate in accordance with the law mentioned, but in conformity with any other law which we might presently conceive, whereby not only the image might not bear any likeness to the object seen, but even the images of the same object at different times or distances might not resemble each other, then our knowledge of form would be very defective, for then we might see, for example, a three-cornered figure as a six or twelve-cornered one. With the clear understanding of the mechanism and mode of action of our organs, we remove all doubts as to the *reality* and *truth* of the impressions received from the outside, and thus we bar out—forever, we may hope—that unhealthy speculation and skepticism into which formerly even strong minds were apt to fall.

Let me tell you of another comforting feature. The progress in a measured time is nowadays more rapid and greater than it ever was before. This is quite in accord- a physician, an electrician, an engineer or mechanician or—whatnot—a mathematician or a financier; for it was he who wrought all these wonders and grandeur we are witnessing. It was he who abolished that small, pedantic, narrow-grooved school teaching which made of an aspiring student a galley-slave, and he who allowed freedom in the choice of subject of study according to one's pleasure and inclination, and so facilitated development.

Some, who delight in the exercise of the powers of criticism, call this an assymetrical development, a degeneration or departure from the normal, or even a degradation of the race. But they are mistaken. This is a welcome state of things, a blessing, a wise subdivision of labors, the establishment of conditions most favorable to progress. Let one concentrate all his energies in one single great effort, let him perceive a single truth, even though he be consumed by the sacred fire, then millions of less gifted men can easily follow. Therefore it is not as much quantity as quality of work which determines the magnitude of the progress.

It was the artist, too, who awakened that broad philanthropic spirit which, even in old ages, shone in the teachings of noble reformers and philosophers, that spirit which makes men in all departments and positions work not as much for any material benefit or compensation—though reason may command this also—but chiefly for the sake of success, for the pleasure there is in achieving it and for the good they might be able to do thereby to their fellow-men. Through his influence types of men are now pressing forward, impelled by a deep love for their study, men who are doing wonders in their respective branches, whose chief aim and enjoyment is the acquisition and spread of knowledge, men who look far above earthly things, whose banner is Excelsior! Gentlemen, let us honor the artist, let us thank him, let us drink his health!

Now, in all these enjoyable and elevating features which characterize modern intellectual development, electricity, the expansion of the science of electricity, has been a most potent factor. Electrical science has revealed to us the true nature of light, has provided us with innumerable appliances and instruments of precision, and has thereby vastly added to the exactness of our knowledge. Electrical science has disclosed to us the more intimate relation existing between widely different forces and phenomena and has thus led us to a more complete comprehension of Nature and its many manifestations to our senses. Electrical science, too, by its fascination, by its promises of immense realizations, of wonderful possibilities chiefly in humanitarian respects, has attracted the attention and enlisted the energies of the artist; for where is there a field in which his God-given powers would be of greater benefit to his fellow-men than this unexplored, almost virgin, region, where, like in a silent forest, a thousand voices respond to every call?

With these comforting features, with these cheering prospects, we need not look with any feeling of incertitude or apprehension into the future. There are pessimistic men, who, with anxious faces, continuously whisper in your ear that the nations are secretly arming—arming to the teeth; that to progress! Give that valiant warrior opportunities for displaying a more commendable courage than that he shows when, intoxicated with victory, he rushes to the destruction of his fellow-men. Let him toil day and night with a small chance of achieving and yet be unflinching; let him challenge the dangers of exploring the heights of the air and the depths of the sea; let him brave the dread of the plague, the heat of the tropic desert and the ice of the polar region. Turn your energies to warding off the common enemies and dangers, the perils that are all around you, that threaten you in the air you breathe, in the water you drink, in the food you consume. Is it not strange, is it not shame, that we, beings in the highest state of development in this our world, beings with such immense powers of thought and action, we, the masters of the globe, should be absolutely at the mercy of our unseen foes, that we should not know whether a swallow of food or drink brings joy and life or pain and destruction to us! In this most modern and sensible warfare, in which the bacteriologist leads, the services electricity will render will prove invaluable. The economical production of high-frequency currents, which is now an accomplished fact, enables us to generate easily and in large quantities ozone for the disinfection of the water and the air, while certain novel radiations recently discovered give hope of finding effective remedies against ills of microbic origin, which have heretofore withstood all efforts of the physician. But let me turn to a more pleasant theme.

I have referred to the merging together of the various sciences or departments of research, and to a certain perception of intimate connection between the manifold and apparently different forces and phenomena. Already we know, chiefly through the efforts of a bold pioneer, that light, radiant heat, electrical and magnetic actions are closely related, not to say identical. The chemist professes that the effects of combination and separation of bodies he observes are due to electrical forces, and the physician and physiologist will tell you that even life's progress is electrical. Thus electrical science has gained a universal meaning, and with right this age can claim the name "Age of Electricity."

I wish much to tell you on this occasion—I may say I actually burn for desire of telling you—what electricity really *is*, but I have very strong reasons, which my co-workers will best appreciate, to follow a precedent established by a great and venerable philosopher, and I shall not dwell on this purely scientific aspect of electricity.

There is another reason for the claim which I have before stated which is even more potent than the former, and that is the immense development in all electrical branches in more recent years and its influence upon other departments of science and industry. To illustrate this influence I only need to refer to the steam or gas engine. For more than half a century the steam engine has served the innumerable wants of man. The work it was called to perform was of such variety and the conditions in each case were so different that, of necessity, a great many types of engines have resulted. In the vast majority of cases the problem put before the engineer was not, as it should have been, the

generator and motor ... engine, though improved in many particulars, is not radically changed, and even now has the same objectionable features and limitations. To do away with these as much as possible, a new type of engine is being perfected in which more favorable conditions for economy are maintained, which expands the working fluid with utmost rapidity and loses little heat on the walls, an engine stripped of all usual regulating mechanism—packings, oilers and other appendages—and forming part of an electric generator; and in this type, I may say, I have implicit faith.

The gas or explosive engine has been likewise profoundly affected by the commercial introduction of electric light and power, particularly in quite recent years. The engineer is turning his energies more and more in this direction, being attracted by the prospect of obtaining a higher thermodynamic efficiency. Much larger engines are now being built, the construction is constantly improved, and a novel type of engine, best suitable for the generation of electricity, is being rapidly evolved.

There are many other lines of manufacture and industry in which the influence of electrical development has been even more powerfully felt. So, for instance, the manufacture of a great variety of articles of metal, and especially of chemical products. The welding of metals by electricity, though involving a wasteful process, has, nevertheless, been accepted as a legitimate art, while the manufacture of metal sheet, seamless tubes and the like affords promise of much improvement. We are coming gradually, but surely, to the fusion of bodies and reduction of all kinds of ores—even of iron ores—by the use of electricity, and in each of these departments great realizations are probable. Again, the economical conversion of ordinary currents of supply into high-frequency currents opens up new possibilities, such as the combination of the atmospheric nitrogen and the production of its compounds; for instance, ammonia and nitric acid, and their salts, by novel processes.

The high-frequency currents also bring us to the realization of a more economical system of lighting; namely, by means of phosphorescent bulbs or tubes, and enable us to produce with these appliances light of practically any candle-power. Following other developments in purely electrical lines, we have all rejoiced in observing the rapid strides made, which, in quite recent years, have been beyond our most sanguine expectations. To enumerate the many advances recorded is a subject for the reviewer, but I can not pass without mentioning the beautiful discoveries of Lenard and Roentgen, particularly the latter, which have found such a powerful response throughout the scientific world that they have made us forget, for a time, the great achievement of Linde in Germany, who has effected the liquefaction of air on an industrial scale by a process of continuous cooling; the discovery of argon by Lord Rayleigh and Professor Ramsay, and the splendid pioneer work of Professor Dewar in the field of low temperature research. The fact that the United States have contributed a very liberal share to this prodigious progress must afford to all of us great satisfaction. While honoring

the workers in other countries and all those who, by profession or inclination, are devoting themselves to strictly scientific pursuits, we have particular reasons to mention with gratitude the names of those who have so much contributed to this marvelous development of electrical industry in this country. Bell, who, by his admirable invention enabling us to transmit speech to great distances, has profoundly affected our commercial and social relations, and even our very mode of life; Edison, who, had he not done anything else beyond his early work in incandescent lighting, would have proved himself one of the greatest benefactors of the age; Westinghouse, the founder of the commercial alternating system; Brush, the great pioneer of arc lighting; Thomson, who gave us the first practical welding machine, and who, with keen sense, contributed very materially to the development of a number of scientific and industrial branches; Weston, who once led the world in dynamo design, and now leads in the construction of electric instruments; Sprague, who, with rare energy, mastered the problem and insured the success of practical electrical railroading; Acheson, Hall, Willson and others, who are creating new and revolutionizing industries here under our very eyes at Niagara. Nor is the work of these gifted men nearly finished at this hour. Much more is still to come, for, fortunately, most of them are still full of enthusiasm and vigor. All of these men and many more are untiringly at work investigating new regions and opening up unsuspected and promising fields. Weekly, if not daily, we learn through the journals of a new advance into some unexplored region, where at every step success beckons friendly, and leads the toiler on to hard and harder tasks.

But among all these many departments of research, these many branches of industry, new and old, which are being rapidly expanded, there is one dominating all others in importance—one which is of the greatest significance for the comfort and welfare, not to say for the existence, of mankind, and that is the electrical transmission of power. And in this most important of all fields, gentlemen, long afterwards, when time will have placed the events in their proper perspective, and assigned men to their deserved places, the great event we are commemorating to-day will stand out as designating a new and glorious epoch in the history of humanity—an epoch grander than that marked by the advent of the steam engine. We have many a monument of past ages; we have the palaces and pyramids, the temples of the Greek and [illegible] In them is

ience we are driven to the general adoption of a system of energy supply from central stations, and for such purposes the beauties of the mechanical generation of electricity can not be exaggerated. The advantages of this universally accepted method are certainly so great that the probability of replacing the engine dynamos by batteries is, in my opinion, a remote one, the more so as the high-pressure steam engine and gas engine give promise of a considerably more economical thermodynamic conversion. Even if we had this day such an economical coal battery, its introduction in central stations would by no means be assured, as its use would entail many inconveniences and drawbacks. Very likely the carbon could not be burned in its natural form as in a boiler, but would have to be specially prepared to secure uniformity in the current generation. There would be a great many cells needed to make up the electro-motive force usually required. The process of cleaning and renewal, the handling of nasty fluids and gases and the great space necessary for so many batteries would make it difficult, if not commercially unprofitable, to operate such a plant in a city or densely populated district. Again, if the station be erected in the outskirts, the conversion by rotating transformers or otherwise would be a serious and unavoidable drawback. Furthermore, the regulating appliances and other accessories which would have to be provided would probably make the plant fully as much, if not more, complicated than the present. We might, of course, place the batteries at or near the coal mine, and from there transmit the energy to distant points in the form of high-tension alternating currents obtained from rotating transformers, but even in this most favorable case the process would be a barbarous one, certainly more so than the present, as it would still involve the consumption of material, while at the same time it would restrict the engineer and mechanic in the exercise of their beautiful art. As to the energy supply in small isolated places as dwellings, I have placed my confidence in the development of a light storage battery, involving the use of chemicals manufactured by cheap water power, such as some carbide or oxygen-hydrogen cell.

But we shall not satisfy ourselves simply with improving steam and explosive engines or inventing new batteries; we have something much better to work for, a greater task to fulfill. We have to evolve means for obtaining energy from stores which are forever inexhaustible, to perfect methods which do not imply consumption and waste of any material whatever. Upon this great [illegible] which I have long ago recog-

would judge them more justly if you would have devoted your life to them, as I have done. With ideas it is like with dizzy heights you climb: At first they cause you discomfort and you are anxious to get down, distrustful of your own powers; but soon the remoteness of the turmoil of life and the inspiring influence of the altitude calm your blood; your step gets firm and sure and you begin to look—for dizzier heights. I have attempted to speak to you on "Electricity," its development and influence, but I fear that I have done it much like a boy who tries to draw a likeness with a few straight lines. But I have endeavored to bring out one feature, to speak to you in one strain which I felt sure would find response in the hearts of all of you, the only one worthy of this occasion—the humanitarian. In the great enterprise at Niagara we see not only a bold engineering and commercial feat, but far more, a giant stride in the right direction as indicated both by exact science and philanthropy. Its success is a signal for the utilization of water powers all over the world, and its influence upon industrial development is incalculable. We must all rejoice in the great achievement and congratulate the intrepid pioneers who have joined their efforts and means to bring it about. It is a pleasure to learn of the friendly attitude of the citizens of Buffalo and of the encouragement given to the enterprise by the Canadian authorities. We shall hope that other cities, like Rochester on this side and Hamilton and Toronto in Canada, will soon follow Buffalo's lead. This fortunate city herself is to be congratulated. With resources now unequaled, with commercial facilities and advantages such as few cities in the world possess, and with the enthusiasm and progressive spirit of its citizens, it is sure to become one of the greatest industrial centers of the globe.

Editors Enjoy a Trolley Ride.

The Republican Editorial Association, of the State of New York, held its annual meeting in this city last week. They devoted the afternoon of Thursday to a trolley ride over Brooklyn in the beautiful parlor trolley cars which President Rossiter, of the Brooklyn Street Railway Company, provided for the occasion. Lunch was served in the cars and it was a very enjoyable as well as novel [illegible]

PERSONAL.

Mr. F. Laughlin, of the Solar Carbon and Manufacturing Company, Pittsburgh, came to New York city last week and made his headquarters at the Hotel Imperial.

Miss Bessie Orne and Mr. F. S. Burke, general manager of the Crown Woven Wire Brush Company, of Salem, Mass., were married at St. Peter's Church, Salem, on January 14.

Col. S. G. Booker, superintendent of the Phœnix Carbon Manufacturing Company, of St. Louis, spent the past week in New York and Boston. His many friends in these cities gave him a cordial welcome.

The West End Street Railway Company, of Boston, has retained Everett W. Burdett to act as legislative counsel at the State House this Winter. He is also counsel for the Boston Electric Light Company at the State House.

Mr. E. T. Copeland, the well known steam-power engineer and contractor, is the eastern representative of the Ball Engine Company, of Erie, Pa. Mr. Copeland's headquarters are at 39 Cortlandt street, New York.

Mr. E. Ward Wilkins, of the firm of Partrick & Carter Company, the well known Philadelphia manufacturers of electrical house goods and general supplies, has started on an extensive western trip, stopping at many of the principal cities between Chicago and San Francisco.

Mr. D. G. Scott, formerly with the American Electrical Works, is [illegible]

But among all these many departments of research, these many branches of industry, new and old, which are being rapidly expanded, there is one dominating all others in importance—one which is of the greatest significance for the comfort and welfare, not to say for the existence, of mankind, and that is the electrical transmission of power. And in this most important of all fields, gentlemen, long afterwards, when time will have placed the events in their proper perspective, and assigned men to their deserved places, the great event we are commemorating to-day will stand out as designating a new and glorious epoch in the history of humanity—an epoch grander than that marked by the advent of the steam engine. We have many a monument of past ages; we have the palaces and pyramids, the temples of the Greek and the cathedrals of Christendom. In them is exemplified the power of men, the greatness of nations, the love of art and religious devotion. But that monument at Niagara has something of its own, more in accord with our present thoughts and tendencies. It is a monument worthy of our scientific age, a true monument of enlightenment and of peace. It signifies the subjugation of natural forces to the service of man, the discontinuance of barbarous methods, the relieving of millions from want and suffering. No matter what we attempt to do, no matter to what fields we turn our efforts, we are dependent on power. Our economists may propose more economical systems of administration and utilization of resources, our legislators may make wiser laws and treaties, it matters little; that kind of help can be only temporary. If we want to reduce poverty and misery, if we want to give to every deserving individual what is needed for a safe existence of an intelligent being, we want to provide more machinery, more power. Power is our mainstay, the primary source of our many-sided energies. With sufficient power at our disposal we can satisfy most of our wants and offer a guaranty for safe and comfortable existence to all, except perhaps to those who are the greatest criminals of all—the voluntarily idle.

The development and wealth of a city, the success of a nation, the progress of the whole human race, is regulated by the power available. Think of the victorious march of the British, the like of which history has never recorded. Apart from the qualities of the race, which have been of great moment, they own the conquest of the world] to—coal. For with coal they produce their iron; coal furnishes them light and heat; coal drives the wheels of their immense manufacturing establishments, and coal propels their conquering fleets. But the stores are being more and more exhausted, the labor is getting dearer and dearer, and the demand is continuously increasing. It must be clear to every one that soon some new source of power supply must be opened up, or that at least the present methods must be materially improved. A great deal is expected from a more economical utilization of the stored energy of the carbon in a battery; but while the attainment of such a result would be hailed as a great achievement, it would not be as much of an advance towards the ultimate and permanent method of obtaining power as some engineers seem to believe. By reasons both of economy and conven-

ro'ating transformers, but even in this most favorable case the process would be a barbarous one, certainly more so than the present, as it would still involve the consumption of material, while at the same time it would restrict the engineer and mechanic in the exercise of their beautiful art. As to the energy supply in small isolated places as dwellings, I have placed my confidence in the development of a light storage battery, involving the use of chemicals manufactured by cheap water power, such as some carbide or oxygen-hydrogen cell.

But we shall not satisfy ourselves simply with improving steam and explosive engines or inventing new batteries; we have something much better to work for, a greater task to fulfill. We have to evolve means for obtaining energy from stores which are forever inexhaustible, to perfect methods which do not imply consumption and waste of any material whatever. Upon this great possibility, which I have long ago recognized, upon this great problem, the practical solution of which means so much for humanity, I have myself concentrated my efforts since a number of years, and a few happy ideas which came to me have inspired me to attempt the most difficult, and given me strength and courage in adversity. Nearly six years ago my confidence had become strong enough to prompt me to an expression of hope in the ultimate solution of this all-dominating problem. I have made progress since, and have passed the stage of mere conviction such as is derived from a diligent study of known facts, conclusions and calculations. I now feel sure that the realization of that idea is not far off. But precisely for this reason I feel impelled to point out here an important fact, which I hope will be remembered. Having examined for a long time the possibilities of the development I refer to, namely, that of the operation of engines on any point of the earth by the energy of the medium, I find that even under the theoretically best conditions such a method of obtaining power can not equal in economy, simplicity and many other features the present method, involving a conversion of the mechanical energy of running water into electrical energy and the transmission of the latter in the form of currents of very high tension to great distances. Provided, therefore, that we can avail ourselves of currents of sufficiently high tension, a waterfall affords us the most advantageous means of getting power from the sun sufficient for all our wants, and this recognition has impressed me strongly with the future importance of the water power, not so much because of its commercial value, though it may be very great, but chiefly because of its bearing upon our safety and welfare. I am glad to say that also in this latter direction my efforts have not been unsuccessful, for I have devised means which will allow us the use in power transmission of electro-motive forces much higher than those practicable with ordinary apparatus. In fact, progress in this field has given me fresh hope that I shall see the fulfillment of one of my fondest dreams; namely, the transmission of power from station to station without the employment of any connecting wire. Still, whatever method of transmission be ultimately adopted, nearness to the source of power will remain an important advantage.

Gentlemen, some of the ideas I have expressed may appear to many of you hardly realizable; nevertheless, they are the result of long-continued thought and work. You

possess, and with the enthusiasm and progressive spirit of its citizens, it is sure to become one of the greatest industrial centers of the globe.

Editors Enjoy a Trolley Ride.

The Republican Editorial Association, of the State of New York, held its annual meeting in this city last week. They devoted the afternoon of Thursday to a trolley ride over Brooklyn in the beautiful parlor trolley cars which President Rossiter, of the Brooklyn Street Railway Company, provided for the occasion. Lunch was served in the cars and it was a very enjoyable as well as novel experience for the visiting editors to be whirled through the city of Brooklyn and suburbs while enjoying an excellent repast. After the ride they visited the Brooklyn Navy Yard, and were later entertained at a banquet at the Union League Club, of Brooklyn, through the courtesy of the president of the association, Hon. William Berri, proprietor of the Brooklyn *Standard Union*. The after-dinner speeches at the banquet were of unusual interest and were made by the following eminent gentlemen: Chauncey M. Depew, Elihu Root, Paul Dana, W. J. Arkell, George H. Daniels, Joseph Howard, Jr., Henry Watterson and Lieut. R. E. Peary, U. S. N.

Another Reason Why the Cable Should Go.

[*From the New York Evening Sun.*]

If you stand on a corner and wave your umbrella at a cable car, and it whirls past you without slowing down, don't blame the gripman until you have looked in the newspapers to see how many were injured. It was probably a runaway. The man in front may have been doing his best.

A Belt Manufacturer Assigns.

The assignment is reported of Edwin A. Burgess, a belt manufacturer in Providence, R. I., who did business under the name of A. Burgess & Son.

known steam-power engineer and contractor, is the eastern representative of the Ball Engine Company, of Erie, Pa. Mr. Copeland's headquarters are at 39 Cortlandt street, New York.

Mr. E. Ward Wilkins, of the firm of Partrick & Carter Company, the well known Philadelphia manufacturers of electrical house goods and general supplies, has started on an extensive western trip, stopping at many of the principal cities between Chicago and San Francisco.

Mr. D. G. Scott, formerly with the American Electrical Works, is now representing in New York city the Crefeld Electrical Works, of Boston, manufacturers of magnet, office, annunciator, rubber-covered and weatherproof wires. Mr. Scott's offices are at 136 Liberty street, New York city.

Mr. C. H. Lease, son of Mrs. Mary Elizabeth Lease, the widely known lecturer, has purchased an interest in the Rousseau Electric Works, New York, and will enter actively into the electrical industry. The Rousseau company was established in 1870 and will no doubt be benefited by the addition of Mr. Lease to its staff.

A Busy Factory.

The Adams-Bagnall factory at Cleveland is one of the busiest establishments in the country to-day, both in the arc lamp and incandescent lamp departments. The improved arc lamp of this company is meeting with much favor wherever tried, and the increasing orders have filled every foot of factory space with workmen and moving machinery. The manager of this company, Mr. L. H. Rogers, is greatly pleased, as he has every reason to be, over the successful business with which his company has been greeted. Mr. Thomas C. Adams and Mr. E. J. Bagnall are both actively interested with the company, and the excellence of the product is largely due to their careful, skillful supervision.

Electrical.... Patents.

[Specially reported for this journal by E. S. Duvall, solicitor of patents, Loan and Trust Building, Washington, D. C. Copies of any patent may be secured for 10 cents each.]

ISSUED JANUARY 19, 1897.

575,322 Incandescent lamp socket; R. B. Benjamin, Chicago, Ill.

575,332 Electrically illuminated jugglery apparatus; M. Cronin, London—Transparent Indian clubs and means for illuminating the same, including battery cells in the same.

575,346 Electric railway; W. Grunow, Jr., Bridgeport, Ct.—An underground conduit for electric railways, comprising a metal trough having a flexible cover or top, composed of flexible metal plates, each of which is secured to the sides of the trough and to the depressible rail, said plates being curved inwardly at their adjacent edges, and securely bolted between strips of insulating material, between which is placed a depressible contact rail, on a level with the surface of the track, said conduit being also provided with a conductor situated in the bottom of the conduit and in proximity to said contact rail.

575,354 Electr'c rail bond; W. Jens, Johnstown, Pa.—A rail bond, having a portion of metal similar in nature to the metal of the bond-bar, integrally united to the rail and adapted to have the bond-bar attached thereto.

575,366 Electrical controller; W. H. Morgan, Alliance, Ohio—An open main frame, and an annular open frame within the main frame and an annular series of resistance coils spaced apart and supported on said annular open frame.

575,394 Magneto-telephone; S. D. Field, Stockton, Mass.

575,419 Telegraphy; P. B. Delany, South Orange, N. J.—A chemical telegraph system, in which signaling curren's of both polarites are transmitted, a receiver, comprising separate styluses for recording dots and dashes and the circuit in which they are located, and a polarized relay in shunt circuit therewith, and responding to the changes in polarity of the transmitted signaling impulses to serve as a telltale or indicator.

575,454 Series-multiple controller for electric motors; E. M. Bentley, Lawrence, N. Y.—Comprises a shunt for the two motors containing a resistance, an automatic circuit-breaker placed in the series circuit between the two inner terminals of the shunts and dependent on the volume of current passing therein.

575,479 Electric elevator or hoisting machine; R. M. Hunter, Philadelphia, Pa.

575,523 Push-button; C. O. Mailloux, New York, N. Y.—The combination with the contact mechanism in a push-button or a collection of push-buttons, a case inclosing the same, the circuit terminals of said mechanism located exteriorly to said case, and a removable face-plate covering said terminals.

575,615 Electric motor and device for conducting currents thereto; D. N. Osyor, Newark, Ohio—Consists of the positive and negative conductors of an insulating support, the brackets secured thereto for the conductors, respectively, and the reversible holders interposed between the conductors and the brackets and detachable from the conductors.

575,653 Electrical condenser; J. C. Lee, Brookline, Mass.—A condenser in the form of a flat rectangular solid, having rounded ends, and composed of alternate layers of a conductor and a non-conductor, wound together to constitute plates and dielectric of like contiguity throughout, the conductor layers being provided with suitable terminal attachments.

A Puzzle in Photometry.

[From Progressive Age.]

Suppose a cubical room measuring 10 feet in each direction to be lighted by a single central jet of a certain power. The illumination of the room under these conditions may be supposed to be standard. Now let one side wall of the room be replaced by a mirror. At first sight it would be said the room would be more brilliantly illuminated. But, looking in the mirror, one sees apparently a second room of 1,000 cubic feet volume lighted with standard brilliancy by a second standard jet. Question: (a) Will two standard jets illumine a room of 2,000 cubic feet more brilliantly than one such jet illumines a room of 1,000 cubic feet? (b) If not, is the original room lighted more brilliantly after the mirror is placed than before, or not? (c) If not, why not? Or if so, what is the mathematical relation between the two illuminations?

Advertising Pays.

[From the Dublin World.]

Angry Caller (at newspaper office)—Say, I want that little ad. I gave you two days ago—"Wanted, an electric battery, in good working order"—taken out.

Advertising Clerk—What is the matter? Didn't we put it in the right column?

Angry Caller—Column be dashed! The ad. overdid the business. My house was struck by lightning last night.

American Institute of Electrical Engineers.

The 111th meeting of the Institute was held at 12 West Thirty-first street, January 20, at which President Duncan presided. Seventy-five members and guests were present. The topic for the evening was "Electrically Driven Vehicles," the discussion being opened by Mr. A. L. Riker and participated in by Messrs. Duncan, Reckenzaun, Coho, Corson, Adams, Duryea, Sachs, Van Hoevenbergh and Pope.

WASHINGTON PATENT
GENCY. LARGEST IN THE WORLD.

908-914 G Street, N. W.,
WASHINGTON, D. C.

ee opinion of merit. ELECTRICAL EXPERTS.

PATENTS.

TRADE MARKS.—DESIGNS.—COPYRIGHTS.

N YOU OBTAIN A PATENT?

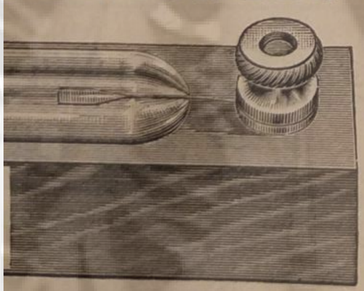
Send me a model or drawing of your inven-, and a description, and I will examine same l advise you promptly. My fees are moderate all Patent matters, and I can obtain a Patent he shortest possible time.

All Patents taken out through me are given cial notice in the leading journals of the country, s bringing same widely before the public without t to inventor.

REFERENCES: "Electrical Review," New York; l Cromlein, Teller Lincoln National Bank, shington, D. C.; Judge Geo. D. Parker, Berkley, ; Second National Bank, Washington, D. C.; K. Leech, U. S. Mint, Philadelphia, Pa.; W. F. vell, Manager and Secretary Water Works mpia, Oregon.

W. S. DUVALL, Solicitor of Patents, Loan and Trust Bldg., WASHINGTON, D. C.

DICATOR.



Smallest,
Cheapest,
Best.

Price,
$1.00
(Cut full size.)

600 Volts.

. 130 Juvenal St., PHILADELPHIA, PA.

WM. MARSHALL,
Manufacturer.

STANDARDS A SPECIALTY.

709 LEXINGTON AVENUE. NEW YORK.

X-RAY SUPPLIES.

CROOKES TUBES.
FLUOROSCOPES.

Stanley's TOEPLER-HOLTZ Machines

will do same work as high-frequency coil at

ONE QUARTER FIRST COST,

With no Installation or Running Expenses.

Send for descriptive pamphlet and prices. They will surely interest you.

Tungstate of Calcium
Photographic Screens.

G. A. FREI & CO.,
17 Bromfield Street, BOSTON.

ROENTGEN RAY APPARATUS

OF ALL KINDS.

ELECTRIC SIGNS.

MINIATURE AND DECORATIVE LAMPS.

CATALOGUES ON APPLICATION.

EDISON DECORATIVE AND MINIATURE LAMP DEPARTMENT, (GENERAL ELECTRIC CO.)
HARRISON, N. J.

AND MOTORS

Our New Direct-Current Tesla Coil

(INDORSED BY LEADING SCIENTISTS.)

Messrs. L. E. Knott Apparatus Company. Urbana, Ohio, Aug. 8, 1896.

Gentlemen: Your high-frequency coil for alternating circuit is giving very satisfactory results in the Roentgen experiments. Our Medical Association has expressed its highest appreciation of the working and results of the Coil. I am safe in saying that my experiments have verified your high claims of its efficiency. Yours truly,

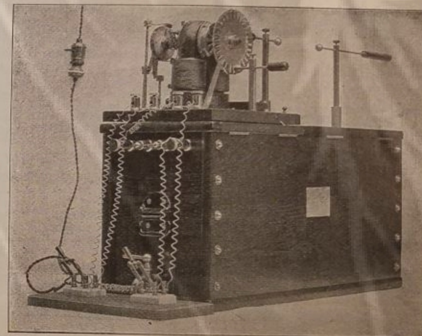
I. N. KEYSER,
Principal Urbana High School.

L. E. KNOTT APPARATUS CO., 14 Ashburton Place, Boston.

NEW X-RAY PAPER,
Superior to Plates.

HIGH-GRADE X-RAY APPARATUS,
Mechanically and Scientifically Perfect.

UNDISPUTED SUPREMACY.



L. E. KNOTT APPARATUS COMPANY'S SPECIAL DIRECT-CURRENT HIGH-FREQUENCY COIL.

OUR DISCOVERY OF NON-PHOSPHORESCENT

highly fluorescent crystals accomplishes the result of showing each image undimmed by previous exposure or phosphorescence, makes clear the most vague shadows which can not be traced when calcium of tungstate is used, and is absolutely instantaneous in effect.

—IMPORTANT TO EVERY X-RAY INVESTIGATOR.—

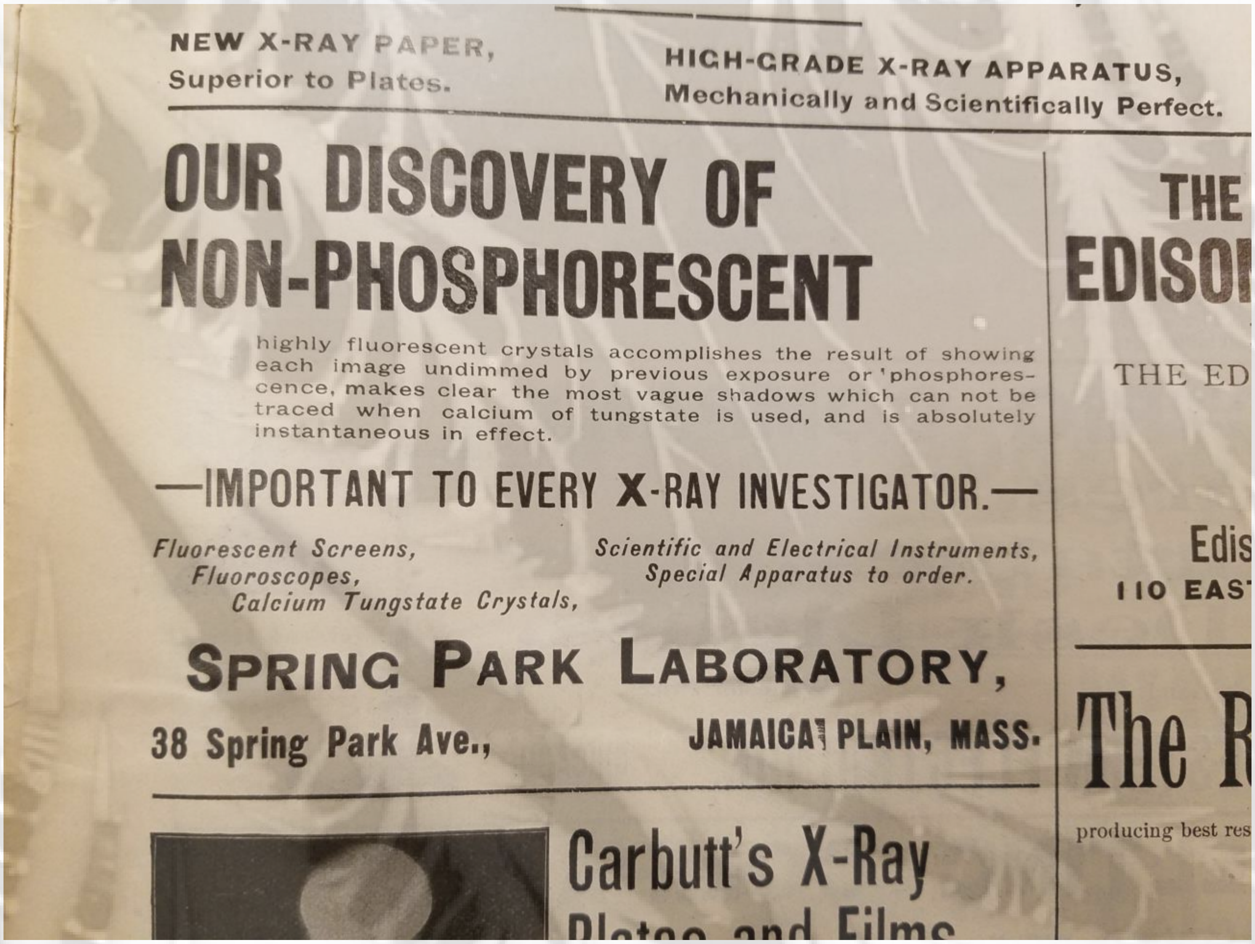
Fluorescent Screens,
Fluoroscopes,
Calcium Tungstate Crystals,

Scientific and Electrical Instruments,
Special Apparatus to order.

THE ONLY GENUINE
EDISON X-RAY APPARATUS

Is manufactured by
THE EDISON MANUFACTURING COMPANY
New and Powerful
Edison X-Ray Focus Tubes
Write for Catalogue

Edison Manufacturing Company
110 EAST 23d STREET NEW YORK



NEW X-RAY PAPER,
Superior to Plates.

HIGH-GRADE X-RAY APPARATUS,
Mechanically and Scientifically Perfect.

OUR DISCOVERY OF NON-PHOSPHORESCENT

highly fluorescent crystals accomplishes the result of showing each image undimmed by previous exposure or 'phosphorescence, makes clear the most vague shadows which can not be traced when calcium of tungstate is used, and is absolutely instantaneous in effect.

—IMPORTANT TO EVERY X-RAY INVESTIGATOR.—

Fluorescent Screens,
Fluoroscopes,
Calcium Tungstate Crystals,

Scientific and Electrical Instruments,
Special Apparatus to order.

SPRING PARK LABORATORY,

38 Spring Park Ave., JAMAICA PLAIN, MASS.

Carbutt's X-Ray
Plates and Films

THE
EDISO

THE ED

Edis
110 EAST

The R

producing best res

Tungstate Crystals, ... *to order.*

110 EAST 23d STREET **NEW YORK**

SPRING PARK LABORATORY,

38 Spring Park Ave., **JAMAICA PLAIN, MASS.**

Carbutt's X-Ray Plates and Films,

INDIVIDUALLY WRAPPED

in light-proof wrappers, so that they may be used under the X-Rays without any further preparation. The composition of the Emulsion is such that the X-Rays are largely *absorbed*, and allows of shorter exposure with the production of more detail in the *Radiograph* Negative than can be obtained on ordinary Dry Plates.

FOR PRICES, ETC.,

JOHN CARBUTT,

Wayne Junction, **PHILADELPHIA**

KEYSTONE DRY PLATE AND FILM WORKS.

When writing, mention ELECTRICAL REVIEW.

THE A B C OF THE X RAY.

By WM. H. MEADOWCROFT.

Cloth and Gold, 75 Cents; Paper, 50 Cents.

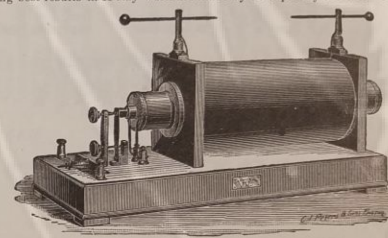
A book for the people. The author of "A B C of Electricity" showed clearly in that work his ability to explain a technical subject for the laymen who know nothing of scientific terms. He has written this work about the X Ray in his usual clear and simple style, and a wide circulation of this highly useful book is assured. The text is beautifully embellished with fine engravings, and nothing is omitted that will give the public a clear knowledge of this remarkable discovery of Prof. Roentgen. This new and up to-date book sent to any address in the United States, postage paid, on receipt of price.

Address **ELECTRICAL REVIEW,**

Times Building, 41 Park Row, **NEW YORK.**

The Ritchie Induction Coils

producing best results in X-Ray work are made by us expressly for this work.



All our coils give a spark from one to two inches above rating. It is known that the founder of this company invented the adopted method of induction coil winding in 1853.

Send for prices and information; catalogue of fine electrical and scientific instruments free.

E. S. RITCHIE & SONS,

Brookline, - - - - - Mass.

OUR AUXILIARY CROOKES TUBES

are the result of many experiments and are being accepted by scientists and professors for long life, strong rays, and requiring less energy. Fully guaranteed.

GREEN & BAUER,

MANUFACTURERS OF FLUOROSCOPES, SCREENS AND COMPLETE OUTFITS,

356 ASYLUM STREET, HARTFORD, CT.

The Standard Edison Fluoroscopes and Fluorescence Screens,

MANUFACTURED BY

AYLSWORTH & JACKSON, ORANGE, N. J.

ILLUSTRATED

ELECTRICAL REVIEW

A Journal of Scientific and Electrical Progress.

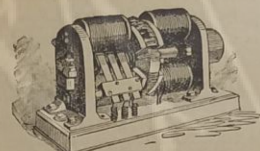
Vol. XXXI.—No. 6. | NEW YORK, WEDNESDAY, AUGUST 11, 1897. | TEN CENTS A COPY. THREE DOLLARS A YEAR.

THE
BRUSH ELECTRIC
COMPANY.

BRUSH

THE
BRUSH ELECTRIC
COMPANY.

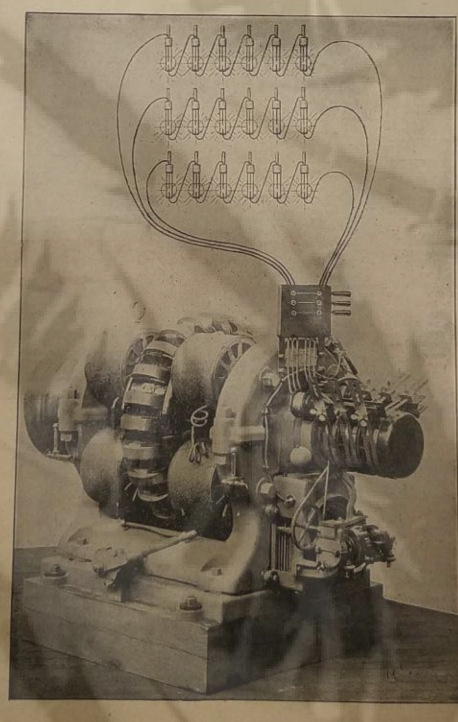
Brush apparatus has been on the market for 20 years. A majority of customers order supply parts direct from us. Many do not. We want this trade and are reducing our prices in order to secure it. Ask for quotations and send orders to the nearest Sales Office.



FIRST BRUSH ARC DYNAMO, 1877.

SALES OFFICES:
Schenectady, N. Y.
Cleveland, Ohio.
Boston, Mass., 180 Summer Street.
New York, N. Y., 44 Broad Street.
Philadelphia, Pa., 509 Arch Street.
Cincinnati, Ohio, 420 West Fourth Street.
Chicago, Ill., Monadnock Building.
St. Louis, Mo., Wainwright Building.
Atlanta, Ga., Equitable Building.
Denver, Colo., Kittredge Building.
San Francisco, Cal., 15 First Street.
Toronto, Ont., Canadian General Electric Company, Ltd.,
Pittsburgh, Pa., Carnegie Building.

Many stations have exchanged all their small units for large Brush arc dynamos. Among them are the Brooklyn-Citizens with 3,000 lights capacity, Brooklyn-Municipal 800, Newark 3,000, Cleveland 1,800, Philadelphia Brush 1,500, Philadelphia-Northern 1,300, Buffalo 1,500, Worcester 1,400, Toronto 900, Quebec 625, Harrisburg 750, Erie 750, Albany 500, Troy 500, Paterson 500, City of Chicago 400, John Wanamaker 625, Carnegie Steel Co. 500.



BRUSH MULTI-CIRCUIT 125-LIGHT ARC DYNAMO, 1897.

Over 40,000 lights capacity in large Brush arc dynamos sold. A large proportion of them using Multi-Circuit Dynamos.

The newly designed Brush dynamos have the following capacities: 55, 80, 100, 125, 240, 300, 2,000-candle-power lights; 45, 85, 120, 160, 1,200-candle-power lights.

Brush arc lamps were first used in 1877. More of them being sold to-day than ever before.

Two or more separate circuits run direct from one dynamo with any distribution of load on the different circuits.

The advantages are absolute flexibility in handling of circuits; reduction of high voltages on circuits run from large dynamos; use of large units with corresponding increase of efficiency; saving in floor space, oil, belts, shafting, pulleys, attendance.

ILLUSTRATED
ELECTRICAL REVIEW
A Journal of Scientific and Electrical Progress.

VOL. 31. No. 6. WEEKLY. NEW YORK, WEDNESDAY, AUGUST 11, 1897. $3 PER ANNUM. Single Copies, 10 Cents.

 Entered at Post Office, New York, as Mail Matter of the Second Class.

VIEWS, NEWS AND INTERVIEWS.

The telephone cable running from the Battery to Governor's Island parted the other day, probably because some craft ran afoul of it. Three men were sent out from the Battery in a rowboat to grapple for the broken ends. They were unable to raise them. Then one of the men, Leon Cholet, who is an expert diver, put on a bathing suit and vanished under water, nearly 25 feet. He made a line fast to one of the broken ends and it was hauled up. He came up for a breathing spell, and then went down and got the other end. The ends were spliced and the repaired cable was lowered to the river bottom.

Mashonaland natives, who are now fighting the British, are pulling down the African transcontinental telegraph wires and cutting them up into bullets.

M. Bergonie, of Bordeaux, has recently made some researches into the action of the X rays upon the progress of pulmonary tuberculosis. The patients were laid out on beds, and the surface of the skin being covered with a light covering, the Crookes tube was placed over the affected region at a distance of 20 centimeters. The exposures lasted for 10 minutes and resulted in no injury to the skin. In five of the patients only was the treatment persevered with. In two of these, where acute phthisis chanced to be aggravated by the results of alcoholism and poor living, there was no improvement whatever either in the general or the local conditions. Three chronic cases of pulmonary tuberculosis showed some amelioration of general condition, but no alteration at the seat of mischief and no arrest of the disease. In three other cases the rays had no appreciable action. The bacillus of Koch seems not to have been modified in its behavior, an observation which was supported recently at the Biological Society by M. Blaise, who read a note affirming that the X rays had absolutely no action whatever upon microbic cultures.

A press dispatch states that a franchise has been granted to the Hon. Irvine Howebart and associates to construct an electric line between Colorado Springs, Colo., and Cripple Creek, a distance of 30 miles. The franchise also empowers the new railroad to obtain its power from the water system of Colorado Springs. The power will be generated by the fall of water in coming down in pipes from the Beaver lakes, the headwaters of the city system, located on Pike's Peak, at an altitude of 12,000 feet. The city's water will be protected from contamination. Mr. Howebart is in Europe floating the bonds necessary for the construction of the road, which will cost $1,500,000. Work on grading has begun. The proposed road will have grades in places as high as 13½ per cent.

This advertisement recently appeared in a Dundee, Scotland, paper:

"Man wanted to attend Cows, and work Electric Light, and make himself generally useful. Married man with no (or small) family preferred.—Apply," etc.

A fine of $25 was recently imposed by Justice Van Wart in the Second District Civil Court, Williamsburgh, on the Nassau Electric Railroad Company, of Brooklyn, N. Y., for a violation of the fender ordinance. The action was begun several months ago by the city through the Corporation Counsel as a test case.

"LA LORGNETTE HUMAINE."

AN X-RAY DEVICE IN USE BY THE FRENCH CUSTOMS AUTHORITIES.

The Electrical Review some weeks ago mentioned the fact that the French customs officers were experimenting with an X-ray apparatus designed to detect dutiable articles concealed about the clothing of a traveler or in sealed packages. The accompanying illustrations show this apparatus in an improved form devised by Prof. Gaston Séguy and which recently underwent successful tests at the Pavillon de Rohan and the Gare du Nord. The apparatus consists of a square case of the dimensions of an ordinary soap box, with a sliding front, upon which rests the Crookes tube holder. Inside the case is the accumulator, from which, by a single turn of a knob, the electric current passes through insulated wires into the tube, thus producing the rays.

The "lorgnette humaine," or fluorescent stereoscope, through which, in the illustrations herewith, one of the individuals is seen peering, constitutes the most important feature of Professor Séguy's improvement. With the aid of this simple device the

French Customs Officer Inspecting a Woman's Hat and Hair by Means of X-Ray Apparatus.

French Customs Officer Examining a Hand-Satchel by Means of X-Ray Apparatus.

parted the other day, probably because some craft ran afoul of it. Three men were sent out from the Battery in a rowboat to grapple for the broken ends. They were unable to raise them. Then one of the men, Leon Cholet, who is an expert diver, put on a bathing suit and

and resulted in no injury to the skin. In five of the patients only was the treatment persevered with. In two of these, where acute phthisis chanced to be aggravated by the results of alcoholism and poor living, there was no improvement whatever either in the general or the local conditions.

French Customs Officer Inspecting a Woman's Hat and Hair by Means of X-Ray Apparatus.

vanished under water, nearly 25 feet. He made a line fast to one of the broken ends and it was hauled up. He came up for a breathing spell, and then went down and got the other end. The ends were spliced

Three chronic cases of pulmonary tuberculosis showed some amelioration of general condition, but no alteration at the seat of mischief and no arrest of the disease. In three other cases the rays had no appreci-

fall of water in coming down in pipes from the Beaver lakes, the head-waters of the city system, located on Pike's Peak, at an altitude of 12,000 feet. The city's water will be protected from contamination. Mr. Howebart is in Europe floating the bonds necessary for the construction of the road, which will cost $1,500,000. Work on grading has begun. The proposed road will have grades in places as high as 13½ per cent.

This advertisement recently ap-

The Electrical Review some weeks ago mentioned the fact that the French customs officers were experimenting with an X-ray apparatus designed to detect dutiable articles concealed about the clothing of a traveler or in sealed packages. The accompanying illustrations show this apparatus in an improved form devised by Prof. Gaston Sèguy and which recently underwent successful tests at the Pavillon de Rohan and the Gare du Nord. The apparatus

French Customs Officer Examining a Hand-Satchel by Means of X-Ray Apparatus.

examination of objects by means of the X-ray apparatus in broad daylight is accomplished without difficulty. The operator adjusts the stereoscope to his eyes in any light, and the objects placed between the fluorescent screen at the base of his holder and the Crookes tube become as clear and visible as if the room were entirely darkened. These advantages have been made clear to the French Government, and have led to the adoption of the machine for various purposes.

The chief advantage of the "lorgnette humaine" is that it simplifies the application of the X ray to the extent of permitting the general use of Professor Roentgen's discovery without the trouble and expense heretofore attendant upon all experiments of the kind. One of its most important *rôles* will be in the customs service. That is clear, from the fact that the bulk of the Paris experiments, both in the office of the chief of the French customs, Monsieur Pallain, and at the Gare du Nord, were undertaken with a view to ascertaining the value of the invention as applied to the inspection of baggage and merchandise. The photographs published here illustrate the various phases of these tests. In one picture we see the inspection of a woman's hat and hair — favorite hiding-places for jewelry, diamonds, etc., among the smuggling fraternity; a second picture shows us the method of inspecting hand-satchels, which also applies to all kinds of baggage.

The tests disclosed the presence of all metallic objects, gems, tobacco and cigars, and even of numerous textile fabrics, fine laces and brocades. It was shown that with the help of the "lorgnette humaine" certain adulterations of wines and liquors could be readily detected; also the quality of certain dyed silks. Finally —and this is of some importance, in this age of bombs and dynamite—it was ascertained that an infernal machine, no matter how constructed, would not resist the all-revealing light, but would at once surrender its grim secret under its irresistible spell!

The custom-house inspector will no longer trample roughshod on our feelings. He will disappear forever, and in his place will come a mild and innocuous personage with something that looks like an opera-glass in his hand. If you have told the truth and have nothing to declare, this newcomer will just take a fluorescent peep at your belongings and disappear from view like a fleeting shadow.

We are indebted to *Leslie's Weekly* for the above particulars and the engravings illustrating this interesting apparatus.

Work on the immense dam in Trowbridge township, Mich., will soon begin and will probably give work to 200 men. The projector, Charles Frisbie, of Jackson, says there will be built one of the largest electric plants in the State to generate power for factories and lighting. The dam will be 300 feet long and 20 feet high. The flowage land consists of about 1,000 acres and cost Mr. Frisbie $25,-000.

Electricity in Garvin's Machine Shop.

The adaptation of electric motors for power purposes as made by the Garvin Machine Company in the new "Garvin" Building, New York city, is excellent, in as much as each of the eight floors used for power have motors operating independently of the others. By this arrangement the usual heavy losses of power in factories as the result of much belting and shafting is avoided. Motors of the Crocker-Wheeler type of 30 horse-power are used, and power is generated near the factory. Altogether 11 motors are used in the building.

Last year this company suffered the destruction by fire of their entire building on Laight street, and the new structure at Spring and Varick streets is one of the most modern and complete establishments, which is exclusively used by a mechanical company, of any in the world. The building, which is of handsome gray stone, eight stories in height, covering an entire block, is equipped throughout with every facility for producing the line of machines and machine tools made by this company. The show rooms on the ground floor are very commodious and take in the entire area. Every modern convenience has been installed, including a telephone system of 26 stations, and call bells connecting all departments. The offices are on the second floor in front, and include several suites of handsome private rooms reserved for members of the firm, which adjoin the main offices for the various clerical departments. Two freight and one passenger elevator, run by electricity, are in constant use, and also an excellent electric light system. The company employs in these shops 450 men.

THE "GARVIN" BUILDING, NEW YORK.

A recent trolley party, under the leadership of Senator George F. Hoar, made a round trip from Boston to Gloucester, Mass., a distance of nearly 75 miles.

THE ECONOMY AND UTILITY OF ELECTRICAL COOKING APPARATUS.

READ AT THE FOURTEENTH GENERAL MEETING OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, ELIOT, ME., JULY 26-28, 1897, BY JOHN PRICE JACKSON.

The tests of electrical cooking apparatus detailed in this paper were made with the hope of obtaining a method of cooking that would be satisfactory with a minimum risk of fire. During the past Winter a serious fire, which might readily have become disastrous, occurred in one of the buildings of the college with which the writer is connected, caused by the use of an alcohol stove. As this institution is lighted and furnished with power by electricity, it was naturally felt that such a danger should be avoided, if possible, by the use of electrical appliances. It was also desired to find out whether at least a portion of the cooking in the woman's department of the college could not be done satisfactorily by electricity.

To settle these points, I procured from the American Electrical Heating Corporation, of Boston (through the courtesy of Mr. Sayles), the following pieces of apparatus:

One oven, 12 inches by 9 inches by 15 inches, having three heats, 3, 10 and 17 amperes respectively.

Three stoves of 2, 4 and 5 amperes respectively.

Two flatirons of 1.5 and 6 amperes capacity.

One broiler of 12 amperes capacity.

The pressure used by these is 110 volts.

The stoves are round disks of iron, on the under side of which the heating wires are embedded in a non-conducting, non-combustible compound. The oven is a box, so thoroughly heat-insulated that the outside metal covering never reaches a temperature uncomfortable to the hand. The broiler is made of a corrugated metal surface, slightly tipped from the horizontal, with a drip groove at the lower edge for catching the meat juices. The flatirons are similar in construction to the stoves, the larger one having a low heat switch, which enables the operator to control the heat.

In all these appliances the heating coils are so arranged that the energy is largely concentrated at useful points. They are also supplied with supports and cases which will not conduct heat.

The efficiencies of the two larger stoves were obtained by heating two pounds of water to the boiling point and measuring the power supplied by a calibrated wattmeter. The cooking vessels used were ordinary stewing pans, with the bases nearly the same size as the tops of the stoves. The efficiencies, considering the ratio between the amount of heat absorbed by the water and the amount received by the stove, were:

For the larger, or No. 1, 48.9 per cent.

For the next size, No. 2, 43.1 per cent.

These efficiencies could be increased by having the pans made to fit the stoves exactly, and still further by carefully covering the pans, lids and exposed portions of the stoves with a non-conductor of heat.

When it is desired to boil water, the best plan is to place an immersion coil in a properly heat-insulated pot; such an arrangement should give an efficiency of from 90 to 100 per cent. We unluckily did not have such a coil at our disposal.

It was impossible to measure the cooking efficiency of the oven, but as it was merely warm on the outside after potatoes or bread had been baked and "done to a turn," the efficiency is high. In baking, the current was turned on and the oven allowed to heat for five minutes before the articles to be cooked were placed within, and the current was turned off from 10 to 20 minutes before the baking was done, when the heat of the oven was sufficient to complete the operation. The broiler was manipulated in much the same manner, thus utilizing the greatest possible amount of heat. This electrical apparatus was used in cooking most of the meals for a family of six for several weeks.

The following table indicates the amount of cooking done for the first breakfast, dinner and supper, respectively, and may be taken as a fair average of the whole period.

All costs have been estimated on the basis of 10 cents per kilowatt hour, the average rate charged for residence electrical supply in a near-by town. The foods were not measured, as it was believed more desirable to determine whether in a long period of cooking the apparatus would prove satisfactory in a family of given size.

The largest stove is designated No. 1; the next size, No. 2; the third size, No. 3; the broiler, B, and the oven, O.

BREAKFAST.

Time	Utensils	Food	Watts
6.55..	No. 1, on	Rolled oats....	
6.55..	No. 2. on	Coffee........	844
7.45..	No. 2, off		
7.45..	No. B, on	Beefsteak.....	1,500
7.55..	No. 2, off	....	1,155
8.05..	No. B, off		

Kilowatt hours, 1.355; cost, 13.55 cents.

DINNER.

Time	Utensils	Food	Watts
10.25.	No. O, on	Beef Roast	..1,610
10.35.		Potatoes..	
11.14.		Pie......	
11.46.	No. 1, on	Asparagus....	1,990
12.05.	No. O, off		
12.05.	No. 2, on	Coffee........	1,180
12.11.	No. B, on	Toast for Aspar.	2,200
12.29.	No. 1, off	....	1,835
12.32.	No. B, off		
12.32.	No. 2, off		

Kilowatt hours, 2.98; cost, 29.8 cents.

SUPPER.

Time	Utensils	Food	Watts
4.59....	No. 1, on	Cocoa......	630
5.15....	No. 2, on	Potato cakes	1,010

Time	Utensils	Food	Watts
5.10	No. B, on	Omelet	2,100
5.22	No. 2, off		1,700
5.26	No. B, off		
5.26	No. 2, on		1,130
5.43	No. 2, off		
5.44	No. 1, off		640

Kilowatt hours, 8.39; cost, 8.39 cents.

Four pies can be baked in the oven at an expenditure of .62 kilowatt hour and a cost of 6.2 cents, or 2.05 cents per pie. Two large loaves of bread were baked with the current on the oven 50 minutes, at an expenditure of 1.22 kilowatt hour, a cost of 12.2 cents, or 6.1 cents per loaf. Four rather small-sized loaves could have been as readily baked; biscuits with about the same expenditure of energy as in the case of pies. The broiler utilized about the same amount of energy for all kinds of meat as indicated in the table.

The result of the whole series of meals was a cost for electricity of 13.1 cents per meal. The heating of water for washing the dishes took an additional .35 of a kilowatt hour per meal, which raises the cost to 16.6 cents per meal.

To determine the relative cost of cooking with electricity and coal, the same foods were cooked on the No. 8 Othello coal stove ordinarily used by the family. The coal was carefully weighed. The results gave an average of 12.6 pounds per meal, which at $5 per ton gives a cost of 3.15 cents per meal.

The result shows the cost of cooking by coal about 19 per cent of the cost of cooking by electricity.

Ironing was done for the same household a number of times. The heavy articles were done with the large iron; while for fancy dresses and small articles, the small iron was used. The average time taken was four hours, and the expenditure of energy in kilowatt-hours was 2.27. This made the cost of the ironing 22.7 cents.

An equal number of tests was made using the coal range, the fuel being carefully weighed. For the same size wash, the ironing took five hours, at a cost of 12.25 cents. This shows the cost of energy by the use of coal to be 54 per cent of that by electricity.

The results of the cooking tests seem to indicate that for the ordinary cooking of a family for the whole year, the expense would be larger than would be ordinarily acceptable, notwithstanding the great advantages in other respects. However, in the following classes their utility should be great:

1. For light housekeeping, such as is practiced in small city apartments, or in many larger houses during the Summer months, no other method presents so many desirable features. The dirt of coal and ashes, disagreeable gases, and abnormal temperatures due to a coal stove are entirely obviated. For such housekeeping a disk stove using 500 or 600 watts and a broiler using about 1,200 watts would be sufficient for a small family and would cost from $20 to $30. A teakettle or immersion coil might be added at a cost of from $6 to $10. A special pair of wires would of necessity have to be run into the cooking room from the house or apartment supply mains. The latter would ordinarily warrant the extra call that would be made upon them in this way. For similar purposes coal oil, gas or gasoline are frequently used, but with the inherent disadvantages of greater heat in the room, offensive odors, comparative uncleanliness and danger.

2. This form of cooking apparatus could be used with facility in boarding-houses and restaurants for purposes which require an even temperature such as is needed in baking griddle cakes, boiling eggs, etc.

3. Where electricity is available, nothing could be more convenient than a small electrical stove, requiring 300 or 400 watts, for the many uses to which at present the alcohol flame is put, such as the afternoon teakettle, chafing-dish, toaster, etc. This use of alcohol is most unsafe as regards danger from fire, and could well be discarded for electricity, which is absolutely safe when properly installed, as well as being more convenient and better in other respects.

4. In the shop, the glue-pot, solder-pot, brazing-iron, etc., can be heated advantageously by electricity, and one of the most gratifying consequences of our experiments has been the decision to put such an equipment in our college shops.

5. The test of the electrical flat-irons showed them more economical than the old form, when the saving of labor is taken into account. Not only is there a saving in time, but the severity of labor is much lessened. Our experience was that a laundress who had used an electrical iron would be exceedingly unwilling to go back to the old form.

A small flat-iron of two or three amperes attached to the ordinary lighting fixture in a dressing-room is a great convenience, and, with an electric tea-kettle and curling-iron, are destined to become essentials in the modern home.

Concerning the questions whether the use of electricity had proved satisfactory in its operations in the cooking tests described, the housekeeper in charge said: "The instruments were excellent in every respect. We were able to cook more rapidly, to keep the heat at just the right point, and could readily prevent over-cooking or under-cooking. While we were using electricity every dish was perfect. When I think of these advantages and of the cleanliness and convenience of the utensils, I sincerely hope that some of them at least may be retained in the house permanently."

The general results of the tests were of such a nature that the writer is warranted in the belief that if central station managers would more generally introduce exhibition equipments of these domestic utensils, a new call on their station capacity would develop, of which the larger proportion would be during the light-load periods.

I wish to acknowledge my indebtedness to Mr. Rudolph F. Kelker, of Harrisburg, Pa., for his valuable aid in carrying out the work briefly described above.

SALES ROOM IN GARVIN BUILDING.

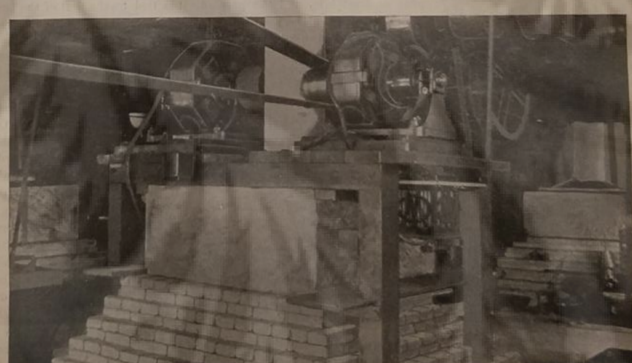
ELECTRIC LIGHT FLASHES.

The incandescent electric light plant, foundry and machine shops of J. F. Enderton, of Aberdeen, Miss., were recently totally destroyed by fire. The loss was about $15,000, with only $2,000 insurance. The origin of the fire is unknown.

At the annual meeting of the Nashua, N. H., Light, Heat and Power Company, the following officers were elected: Directors, Fred W. Estabrook, Jas. H. Tolles, Frank E. Anderson, Geo. E. Anderson and David A. Gregg. At a subsequent meeting of the board it organized the election of F. W. Estabrook, president; F. E. Anderson, treasurer; Jas. H. Tolles, clerk.

There is more work in Topeka, Kas., now than men who can be secured to perform it. Several would-be employers are engaged in a hopeless search for workmen. F. E. Munsell, superintendent of the Edison Electric Illuminating Company, has had this fact demonstrated repeatedly. He has a lot of digging for the new heat mains, but can not obtain the necessary number of men.

The People's Electric Light and Power Company and the Newark Gas Company, of Newark, N. J., capital, $5,000,000, each controlling most of the lighting interests in Essex, Hudson, Bergen, Passaic and Union counties, New Jersey, have consolidated, with a capital of $15,000,000. The United Gas Improvement Company, of Philadelphia, is said to be behind the consolidation, and it is the purpose to ultimately consolidate all the gas and electric power companies of the State, with an aggregate capital of $50,000,000.



MOTOR INSTALLATION, CROCKER-WHEELER TYPE, USED ON EVERY FLOOR OF THE GARVIN FACTORY.

TWO CASES OF "ELECTRIC LIGHT BLINDNESS."

BY ROBERT HILL, SURGEON, ROYAL NAVY, H. M. S. "VICTORY," IN THE LONDON "LANCET."

I venture to forward for publication in the *Lancet* the following cases that have come under my notice lately, hoping that they may be of interest to its readers, and more especially to those engaged in ophthalmic work:

Case 1.—About 1 A. M. on June 1, 1897, I was called hurriedly to see a man who was said to be suffering great pain in his eyes. The man, a stoker, 20 years of age, I found walking round the sick bay of this ship in an agony of pain, with his hands up to his eyes, from which the tears were literally pouring. The lids were kept firmly closed, and all my efforts to see the eyes proved futile until I had dropped in cocaine, which acted like a charm. Five minutes later he could distinguish the number of persons in the room, but not the number of fingers held up. The pupils were moderately dilated (probably due to the cocaine); the palpebral conjunctiva was deeply congested, with but slight reddening of the bulbar conjunctiva; the cornea was clear. I imagined some irritant had been applied, but he denied this, nor could I find any trace of any substance, such as pepper, likely to cause the condition. Cold applications were used, and the patient soon fell asleep. At 8 A. M. his vision was normal, but the conjunctiva was injected, and he complained of a sticky sensation in his eyes. He then gave me the following history. When at work in H. M. S. "Mars" on the afternoon of May 31, he had stopped for about three minutes to look at the electric drill which was being used to bore holes in a steel plate, standing at a distance of from 10 to 12 yards; on resuming his own work everything appeared to him of a deep gold color, but he had no pain or lacrymation. He turned into his hammock at 9 P. M., and woke up in great pain at 12.30.

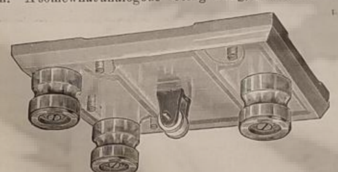
Case 2.—At 9 A. M. on June 1 a stoker, aged 28 years, who had been sleeping on shore, came to the sick bay complaining of his eyes; he stated that he had been working in H.M.S. "Mars" on the previous afternoon, and, like the patient in Case 1, had stopped to see the electric drill working, and had noticed during the remainder of the day that everything appeared of a deep gold color. About 4 A. M. he had jumped out of bed in great pain, and this had lasted about an hour and half. The condition of the eyes was very similar to that described in Case 1—injection of the conjunctiva being the only abnormal condition. Vision was normal.

Ever since the electric light has been in use workers at this trade have been subject to attacks of blindness, and cases have been recorded in which erosion of the cornea has followed the inflammation induced. Dark glasses are now always used by men so employed. The electric drill acts by fusing a hole through the steel, and probably the intensity of the light is greatly increased by the rays of light thrown off by the molten metal. The fact that the work is carried on chiefly in the daylight hides to a casual passer-by the extreme brilliancy of the light, and it is not until the patient experiences abnormal color sensations that he is aware of anything extraordinary. When first this drill was used in Chatham Dockyard, Surgeon P. N. Randall had a few similar cases among the dockyard hands, but as they slept on shore he had no opportunity of observing the acuteness of the pain.

The pathology of this condition has been stated to be similar to that of snow-blindness or desert blindness, and to depend on irritation of the branches of the ophthalmic division of the fifth nerve. In the cases above recorded the irritation would appear to have gone on to absolute paralysis and the pain to have been due to the acute congestion attending the nerves in their action of regaining their normal function. A somewhat analogous train of circumstances is found in the paralysis of the sensory nerves of other parts of the body when exposed to extreme cold, such as the ether spray or frost bite, and the pain in these cases is often very great when the congestion attending the "coming to" of the part takes place. The short period during which the severe pain lasted is also in favor of this analogy. The close sympathy that exists between the second nerve and the branches of the ophthalmic division of the fifth nerve is shown in many common and well known reflexes, such as lacrymation and sneezing on sudden exposure of the eye to a bright light, or, conversely, the dread of light that is caused by any injury to the cornea. In the class of cases described we have a marked instance of the first class of reflex. A temporary paralysis of some of the optic nerve terminals is induced by the exposure to the intense light and heat of the electric drill as shown by the subjective color sensations experienced. The corneal terminals reflexly share in the paralysis; lacrymation and photophobia are absent because the nerve terminals are paralyzed and not merely irritated at the time. After the lapse of a few hours a reaction with temporary congestion is set up as manifested by the acute pain and lacrymation, and probably some mistiness of vision. The longer the exposure to the bright light the profounder the paralysis and the more intense and lasting the reactionary symptoms. These cases are, in fact, analogous to snow-blindness, and, as in them, the pernicious effects of the electric light are probably due to the ultra violet rays of the spectrum.

The McDonald Glass Hanger-Board.

The insulation of appliances used in high-tension series arc lighting is always of the greatest importance, and particularly for inside arc-light wiring, where a dangerous voltage is carried into the building and directly to the lamp. A large number of arc-light hanger-boards have been designed from time to time having for their object better insulation, but it has remained for the McDonald glass hanger-board to secure the most striking results. As shown in the accompanying illustration, the hanger-board consists of glass insulating knobs mounted on a glass base or support. This secures a perfect insulation, which will always remain the same, as moisture or corrosion is not possible. This hanger makes a bright, clean appearance, and can always be kept in that condition. The extra holes shown in the base allow the board to be used with three insulators, as shown, or with only two insulators, one at each end of the board. When a series of lamps is being hung, the board at the end of the series may be used with two insulators, while all the other boards should be used with three insulators. Thus, when the wire reaches the first board, it is tied to the first of the two insulators at the double end; from this point a loop is made for the lamp, and the line wire leaves from the other insulator on the double end. This is repeated on each board of the series until the last board having only two insulators is reached. On this board the line goes first to the insulator at one end of the board, then through the lamp to the insulator at the other end. From this point it starts back out of the building, using as a support the free insulators on all of the boards having three insulating knobs. This makes a neat arrangement of the loops and, at the same time, a perfect insulation of both wires. The McDonald glass hanger-board is being placed on the market by the Electric Appliance Company, of Chicago.



THE McDONALD GLASS HANGER-BOARD FOR ARC LAMPS.

The annual reports of the Union and Westchester electric railway companies, which are controlled by Albany, N. Y., capitalists, show: Union—Gross earnings from operation, $148,-240; operating expenses, $85,720; net earnings, $62,520; other income, $416; gross income, $62,936; fixed charges, $32,611; net income, $30,325; cash on hand, $48,199; profit and loss (surplus), $328,675. Westchester Electric—Gross earnings from operation, $34,-160; operating expenses, $22,680; net earnings, $11,480; fixed charges, $7,-272; net income, $4,216; cash on hand, $1,368; profit and loss (deficiency), $8,321.

TELEPHONE NEWS AND COMMENT.

Alfred Buckman has been appointed manager of the Bell Telephone Company's office in Norwalk, Ohio, to succeed W. H. Harter, who was transferred to Montana.

The neglect of the Standard Telephone Company to commence work on its Camden, N. J., plant is said to be due to complications in Philadelphia. The franchise will probably be abandoned.

Teheran, Persia, is to have a telephone exchange, and a New York house is to supply the instruments. They will have to be carried 800 miles on the backs of mules to get to their destination after landing at Bushire.

The Bell Telephone Company, of Cincinnati, Ohio, or, as it is legally called, the City and Suburban Telegraph Association, is building a telephone line to Brookville, Ind., one of the most flourishing cities in that State. It will run via Hamilton, and will be completed in about four weeks. This will give merchants in Cincinnati an opportunity of reaching several of the best cities and villages in that territory.

The new State Telephone Company, of Detroit, Mich., has completed the purchase of all of that 225 miles of lines now under control of the Co-operative Telephone Company, of Lake Odessa. This company has exchanges in Lake Odessa and Grand Ledge, and its toll lines connect with the exchanges at Grand Rapids and Lansing. The purchase affords an entrance into Ionia, Lansing and Grand Rapids. Several other lines are begun, each of which will carry a traffic agreement with the Detroit Telephone Company.

The possible annexation of the Hawaiian Islands to the United States has aroused more than usual interest in that mid-sea republic. In an appreciative article on Hawaiian life, Mr. Richard Hamilton Potts writes as follows in *Harper's Weekly:*

"To all kinds of entertainment, formal or informal, one is bidden by the telephone—the telephone of a system complete, perfect, and as little inclined to hurry its messages as it ought to be consistently with the general order of things. To be cut off in the middle of a sentence is an aggravation almost unknown. Love-making, gossip, repartee, politics—everything goes through the telephone. Prudence is never learned, and everybody confides in 'Central' as if he were a fond parent."

The motion for injunction in the suit of Cahall vs. Babcock & Wilcox, for infringements of patents, has been decided in favor of the Babcock & Wilcox Company in the United States Court, Western District of Pennsylvania.

Electrical Review

Times Building, 41 Park Row,

P. O. Box 2339. NEW YORK.

EDITOR:
CHARLES W. PRICE.
ASSOCIATE EDITOR:
STEPHEN L. COLES.

REGISTERED CABLE ADDRESS:
"ELECTVIEW," NEW YORK.

1846 "CORTLANDT," TELEPHONE CALL.

WESTERN OFFICE:
CARL E. KAMMEYER, Representative,
1627 MONADNOCK BLOCK, CHICAGO.

LONDON OFFICE:
HENRY W. HALL, Representative,
42 OLD BROAD STREET, LONDON, E. C.
News, Subscriptions and Advertisements.

Subscription to the
ELECTRICAL REVIEW.

One Year, United States and Canada, - $3.00
One Year, Foreign Countries, - - 5.00
Single Copy, - - - - - - - .10

Copies can only be supplied for one year back at 25 cents each.

Special Notice to Advertisers.

CHANGES for advertisements must be in this office by Friday noon for the following week's issue.

NEW ADVERTISEMENTS should be in the office not later than Saturday noon to insure publication the following week.

NEW YORK, AUG. 11, 1897.

CONTENTS.

INDEX OF ADVERTISERS.

A Buffalo junk dealer recently stole 900 feet of live trolley wire out of the lines of the Buffalo, Kenmore & Tonawanda trolley system. Most of us have seen the late Old Hoss Hoey get away with a red-hot stove, but the man who steals live trolley wire must have a nerve several degrees higher than that of the tramp so truly characterized by Hoey.

We congratulate the city of Brooklyn, N. Y., on the possession of a handsome electric fountain located in the Prospect Park Plaza. At the first public exhibition of the beauties of this work of adornment 100,000 citizens were present.

Mr. Thomas B. Dixon is announced as the latest telegraphic inventor. He comes to the front with a method of sextuplex telegraphy, but, as his invention has as yet been described only in the daily press, the proper data on which to base a criticism are not available.

Tesla is quietly pursuing his fruitful labors, and, devoted as he is to the cause of science, remains undisturbed by journalistic sensationalism and consequent criticism of the uninformed. In this issue he again makes a particularly valuable and practical contribution to the important field which Lenard and Roentgen have opened up.

Col. W. L. Strong, former president of the Brush–Swan Electric Company, of New England, will very probably be the first Mayor of the Greater New York. Colonel Strong is the present Mayor of New York city, and his acceptable and successful administration now promises to again make him a candidate, even though he is personally unwilling. We believe he is the man.

PROSPERITY.

There is no doubt about the fact that the wave of prosperity has begun to roll. It behooves every business man to get his affairs in shape to handle a larger fall trade than he has been called upon to meet for four years past.

Our crops are more than usually abundant, and the prices for grain are away up. This means that the farmers will have plenty of money in the fall, and consequently trade will be stimulated. The railroads are doing a great business handling the crops already harvested; in some places there is a car famine.

The tariff bill has been passed and promises to give the government sufficient revenue. Business men in every line have already adapted themselves to its new conditions, and can now proceed with their affairs in confidence.

Labor is in demand. The only croakers left are the loafers and professional Weary Willies.

An electric light superintendent in Topeka, Kas., had more work last week than he could get men to perform. All the large electrical manufacturing companies and most of the smaller ones have their shops full of work and orders to fill. Electrical contractors are looking forward to a tremendous business as soon as the hot weather is over. They base their opinion on inquiries received during the past month. President Edward E. Poor of the National Park Bank of New York city, has received nearly 100 letters from bankers in nearly every State in the Union, written in reply to questions concerning business conditions. They all agree that a great wave of prosperity and good times is sweeping over the country. There is a larger volume of business, more men are at work, and confidence is growing. Prosperity is upon us, and the man who doesn't get his share of it has no one to blame but himself.

note

The few readers of our esteemed contemporary, the *Electrical Engineer*, will, no doubt, be somewhat surprised to learn from its issue of July 29 that Mr. D. McFarlan Moore is only promising now to bring forth improvements "that will place vacuum-tube lighting abreast of incandescent lighting in economy." As far back as October 23, 1895, they were informed editorially that "even in its present condition the system already possesses unquestioned commercial value." And in the issue of April 29, 1896, quoting only one of the many bald assertions, it was editorially stated that, "as to its economy, that point seems to be well disposed of." The ever and ever few readers of our contemporary will be struck by such evidence of conscientiousness and appreciation of journalistic responsibility to the public of these able editors. They will also be profoundly grateful for the most valuable information given about the Moore vibrators, which have been mastered and perfected to be abandoned! The great surprise, however, is the conclusion which they announce that Mr. Moore has reached; namely, that "the solution of the vacuum-tube lighting problem lay in breaking an inductive circuit in vacuum." We are ourselves gratified to finally learn what our ill-advised contemporary supposes to be an invention. Inductive circuits have been broken in vacuum for 40 years or more, ever since the invention of Poggendorf, and vacuum tubes have been used during all that period, and if, without the aid of a novel principle, such solution of the lighting question is reached, it will be the more welcome, as everybody will be free to use it.

TESLA ON THE SOURCE OF ROENTGEN RAYS AND THE PRACTICAL CONSTRUCTION AND SAFE OPERATION OF LENARD TUBES.

To the Editor of Electrical Review:

I have for some time felt that a few indications in regard to the practical construction of Lenard tubes of improved designs, a great number of which I have recently exhibited before the New York Academy of Sciences (April 6, 1897), would be useful and timely, particularly as by their proper construction and use much of the danger attending the experimentation with the rays may be avoided. The simple precautions which I have suggested in my previous communications to your esteemed journal are seemingly disregarded, and cases of injury to patients are being almost daily reported, and in view of this only, were it for no other reason, the following lines, referring to this subject, would have been written before had not again pressing and unavoidable duties prevented me from doing so. A short and, I may say, most unwelcome interruption of the work which has been claiming my attention makes this now possible. However, as these opportunities are scarce, I will utilize the present to dwell in a few words on some other matters in connection with this subject, and particularly on a result of importance which I have reached some time ago by the aid of such a Lenard tube, and which, if I am correctly informed, I can only in part consider as my own, since it seems that practically it has been expressed in other words by Professor Roentgen in a recent communication to the Academy of Sciences of Berlin. The result alluded to has reference to the much disputed question of the source of the Roentgen rays. As will be remembered, in the first announcement of his discovery, Roentgen was of the opinion that the rays which affected the sensitive layer emanated from the fluorescent spot on the glass wall of the bulb; other scientific men next made the cathode responsible; still others the anode, while some thought that the rays were emitted solely from fluorescent powders or surfaces, and speculations, mostly unfounded, increased to such an extent that, despairingly, one would exclaim with the poet:

"O gluecklich wer noch hoffen kann,
Aus diesem Meer des Irrtums aufzutauchen!"

My own experiments led me to recognize that, regardless of the location, the chief source of these rays was the place of the *first* impact of the projected stream of particles within the bulb. This was merely a broad statement, of which that of Professor Roentgen was a special case, as in his first experiments the fluorescent spot on the glass wall was, incidentally, the place of the first impact of the cathodic stream. Investigations carried on up to the present day have only confirmed the correctness of the above opinion, and the place of the first collision of the stream of particles—be it an anode or independent impact body, the glass wall or an aluminum window—is still found to be the principal source of the rays. But, as will be seen presently, it is not the only source.

Since recording the above fact my efforts were directed to finding answers to the following questions: First, is it necessary that the impact body should be within the tube? Second, is it required that the obstacle in the path of the cathodic stream should be a solid or liquid? And, third, to what extent is the velocity of the stream necessary for the generation of and influence upon the character of the rays emitted?

In order to ascertain whether a body located outside of the tube and in the

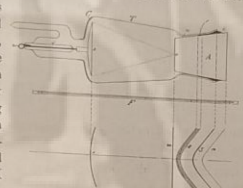


Fig. 1.—Illustrating an Experiment Revealing the Real Source of the Roentgen Rays.

path or in the direction of the stream of particles was capable of producing the same peculiar phenomena as an object located inside, it appeared necessary to first show that there is an actual penetration of the particles through the wall, or otherwise that the actions of the supposed streams, of whatever nature they might be, were sufficiently pronounced in the outer region close to the wall of the bulb as to produce some of the effects which are peculiar to a cathodic stream. It was not difficult to obtain with a properly prepared Lenard tube, having an exceedingly thin window, many and at first surprising evidences of this character. Some of these have already been pointed out, and it is thought sufficient to cite here one more which I have since observed. In the hollow aluminum cap A of a tube as shown in diagram Fig. 1, which will be described in detail, I placed a half-dollar silver piece, supporting it at a small distance from and parallel to the window or bottom of the cap by strips of mica in such a manner that it was not

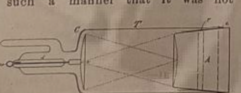


Fig. 2.—Improved Lenard Tube.

touching the metal of the tube, an air space being left all around it. Upon exciting the bulb for about 30 to 45 seconds by the secondary discharge of a powerful coil of a novel type now well known, it was found that the silver piece was rendered so hot as to actually scorch the hand; yet the aluminum window, which offered a very insignificant obstacle to the cathodic stream, was only moderately warmed. Thus it was shown that the silver alloy, owing to its density and thickness, took up most of the energy of the impact, being acted upon by the particles almost identically as if it had been inside of the bulb, and, what is more, indications were obtained, by observing the shadows, that it behaved like a second source of the rays, inasmuch as the outlines of the shadows, instead of being sharp and clear as when the half-dollar piece was removed, were dimmed. It was immaterial for the chief object of the inquiry to decide by more exact methods whether the cathodic particles actually penetrated the window, or whether a new and separate stream was projected from the outer side of the window. In my mind there exists not the least doubt that the former was the case, as in this respect I have been able to obtain numerous additional proofs, upon which I may dwell in the near future.

I next endeavored to ascertain whether it was necessary that the obstacle outside was, as in this case, a solid body, or a liquid, or broadly, a body of measurable dimensions, and it was in investigating in this direction that I came upon the important result to which I referred in the introductory statements of this communication. I namely observed rather accidentally, although I was following up a systematic inquiry, what is illustrated in diagram Fig. 1. The diagram shows a Lenard tube of

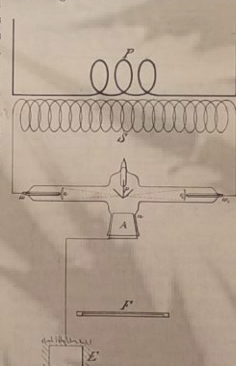


Fig. 3.—Illustrating Arrangement with Improved Double-Focus Tube for Reducing the Injurious Actions.

improved design, consisting of a tube T of thick glass tapering towards the open end, or neck n, into which is fitted an aluminum cap A, and a spherical cathode e, supported on a glass stem s, and platinum wire w sealed in the opposite end of the tube as usual. The aluminum cap A, as will be observed, is not in actual contact with the ground-glass wall, being held at a small distance from the latter by a narrow and continuous ring of tinfoil r. The outer space between the glass and the cap A is filled with cement c, in a manner which I shall later describe. F is a Roentgen screen such as is ordinarily used in making the observations.

Now, in looking upon the screen in the direction from F to T, the dark lines indicated on the lower part of the diagram were seen on the illuminated background. The curved line e and the straight line W were, of course, at once recognized as the outlines of the cathode e and the bottom of the cap A respectively, although, in consequence of a confusing optical illusion, they appeared much closer together than they actually were. For instance, if the distance between e and o was five inches, these lines would appear on the screen about two inches apart, as nearly as I could judge by the eye. This illusion may be easily explained and is quite unimportant, except that it might be of some moment to physicians to keep this fact in mind when making examinations with the screen as, owing to the above effect, which is sometimes exaggerated to a degree hard to believe, a completely erroneous idea of the distance of the various parts of the object under examination might be gained, to the detriment of the surgical operation. But while the lines e and W were easily accounted for, the curved lines t, g, a were at first puzzling. Soon, however, it was ascertained that the faint line a was the shadow of the edge of the aluminum cap, the much darker line g that of the rim of the glass tube T, and t the shadow of the tinfoil ring r. These shadows on the screen F clearly showed that the agency which affected the fluorescent material was proceeding from the space outside of the bulb towards the aluminum cap, and chiefly from the region through which the primary disturbances or streams emitted from the tube through the window were passing, which observation could not be explained in a more plausible manner than by assuming that the air and dust particles outside, in the path of the projected streams, afforded an obstacle to their passage and gave rise to impacts and collisions spreading through the air in all directions, thus producing continuously new sources of the rays. It is this fact which, in his recent communication before mentioned, Roentgen has brought out. So, at least, I have interpreted his reported statement that the rays emanate from the irradiated air. It now remains to be shown whether the air, from which carefully all foreign particles are removed, is capable of behaving as an impact body and source of the rays, in order to decide whether the generation of the latter is dependent on the presence in

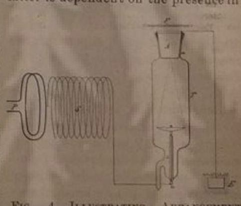


Fig. 4.—Illustrating Arrangement with a Lenard Tube for Safe Working at Close Range.

the air of impact particles of measurable dimensions. I have reasons to think so.

With the knowledge of this fact we are now able to form a more general

(Concluded on page 71.)

TESLA ON THE SOURCE OF ROENTGEN RAYS AND THE PRACTICAL CONSTRUCTION AND SAFE OPERATION OF LENARD TUBES.

To the Editor of Electrical Review:

I have for some time felt that a few indications in regard to the practical construction of Lenard tubes of improved designs, a great number of which I have recently exhibited before the New York Academy of Sciences (April 6, 1897), would be useful and timely, particularly as by their proper construction and use much of the danger attending the experimentation with the rays may be avoided. The simple precautions which I have suggested in my previous communications to your esteemed journal are seemingly disregarded, and cases of injury to patients are being almost daily reported, and in view of this only, were it for no other reason, the following lines, referring to this subject, would have been written before had not again pressing and unavoidable duties prevented me from doing so. A short and, I may say, most unwelcome interruption of the work which has been claiming my attention makes this now possible. However, as these opportunities are scarce, I will utilize the present to dwell in a few words on some other matters in connection with this subject, and particularly on a result of importance which I have reached some time ago by the aid of such a Lenard tube, and which, if I am correctly informed, I can only in part consider as my own, since it seems that practically it has been expressed in other words by Professor Roentgen in a recent communication to the Academy of Sciences of Berlin. The result alluded to has reference to the

will be seen presently, it is not the only source.

Since recording the above fact my efforts were directed to finding answers to the following questions: First, is it necessary that the impact body should be within the tube? Second, is it required that the obstacle in the path of the cathodic stream should be a solid or liquid? And, third, to what extent is the velocity of the stream necessary for the generation of and influence upon the character of the rays emitted?

In order to ascertain whether a body located outside of the tube and in the

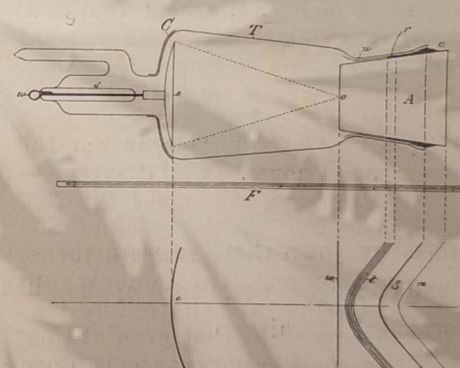


Fig. 1.—Illustrating an Experiment Revealing the Real Source of the Roentgen Rays.

path or in the direction of the stream of particles was capable of producing the same peculiar phenomena as an object located inside, it appeared necessary to first show that there is an actual penetration of the particles through the wall, or otherwise that the actions of the supposed streams, of whatever nature they might be, were sufficiently pronounced in the outer region close to the wall of the bulb as to produce some of the effects which are peculiar to a cathodic stream. It was not difficult to obtain with a properly prepared Lenard tube,

inside
indicat
ing the
a secon
much
instead
when
moved,
materi
inquiry
method
ticles a
or whe
was pr
the wi
exists
former
I have
additio
dwell i

I ne
whethe
obstacl
a solid
a body
and it
directio
importa
in the
this co
served
was foll
what is
The dia

with this subject, and particularly on a result of importance which I have reached some time ago by the aid of such a Lenard tube, and which, if I am correctly informed, I can only in part consider as my own, since it seems that practically it has been expressed in other words by Professor Roentgen in a recent communication to the Academy of Sciences of Berlin. The result alluded to has reference to the much disputed question of the source of the Roentgen rays. As will be remembered, in the first announcement of his discovery, Roentgen was of the opinion that the rays which affected the sensitive layer emanated from the fluorescent spot on the glass wall of the bulb; other scientific men next made the cathode responsible; still others the anode, while some thought that the rays were emitted solely from fluorescent powders or surfaces, and speculations, mostly unfounded, increased to such an extent that, despairingly, one would exclaim with the poet:

> "O gluecklich wer noch hoffen kann,
> Aus diesem Meer des Irrtums aufzutauchen!"

My own experiments led me to recognize that, regardless of the location, the chief source of these rays was the place of the *first* impact of the projected stream of particles within the bulb. This was merely a broad statement, of which that of Professor Roentgen was a special case, as in his first experiments the fluorescent spot on the glass wall was, incidentally, the place of the first impact of the cathodic stream. Investigations carried on up to the present day have only confirmed the correctness of the above opinion, and the place of the first collision of the stream of particles—be it an anode or independent impact body, the glass wall or an aluminum window—is still found to be the principal source of the rays. But, as

located inside, it appeared necessary to first show that there is an actual penetration of the particles through the wall, or otherwise that the actions of the supposed streams, of whatever nature they might be, were sufficiently pronounced in the outer region close to the wall of the bulb as to produce some of the effects which are peculiar to a cathodic stream. It was not difficult to obtain with a properly prepared Lenard tube, having an exceedingly thin window, many and at first surprising evidences of this character. Some of these have already been pointed out, and it is thought sufficient to cite here one more which I have since observed. In the hollow aluminum cap A of a tube as shown in diagram Fig. 1, which will be described in detail, I placed a half-dollar silver piece, supporting it at a small distance from and parallel to the window or bottom of the cap by strips of mica in such a manner that it was not

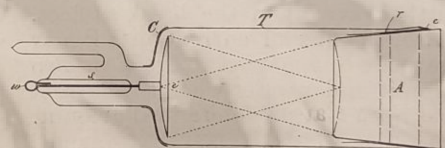


Fig. 2.—Improved Lenard Tube.

touching the metal of the tube, an air space being left all around it. Upon exciting the bulb for about 30 to 45 seconds by the secondary discharge of a powerful coil of a novel type now well known, it was found that the silver piece was rendered so hot as to actually scorch the hand; yet the aluminum window, which offered a very insignificant obstacle to the cathodic stream, was only moderately warmed. Thus it was shown that the silver alloy, owing to its density and thickness, took up most of the energy of the impact, being acted upon by the particles almost identically as if it had been

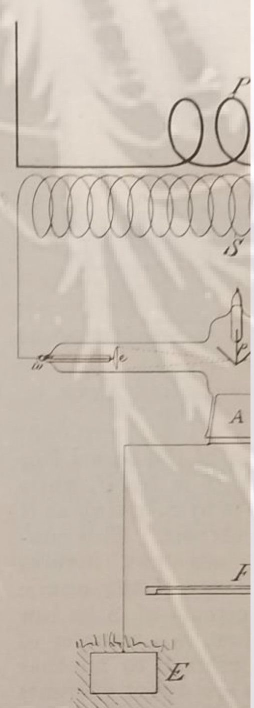
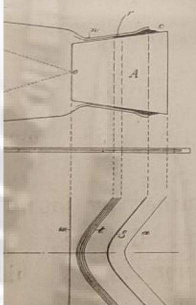


Fig. 3.—Illustrati
with Improved D
for Reducing the

improved design, co
T of thick glass tap
open end, or neck
fitted an aluminum
spherical cathode e
glass stem s, and
sealed in the opposit
as usual. The alumi
be observed, is not
with the ground-g
held at a small di
latter by a narrow
ring of tinfoil r.
between the glass
is filled with cemen
which I shall later
Roentgen screen suc
used in making the
Now, in looking u
the direction from
lines indicated on t
the diagram were see
inated background.

tly, it is not the
he above fact my
d to finding an-
wing questions:
y that the impact
ithin the tube?
l that the obstacle
cathodic stream
iquid? And, third,
he velocity of the
r the generation
on the character
?
in whether a body
e tube and in the

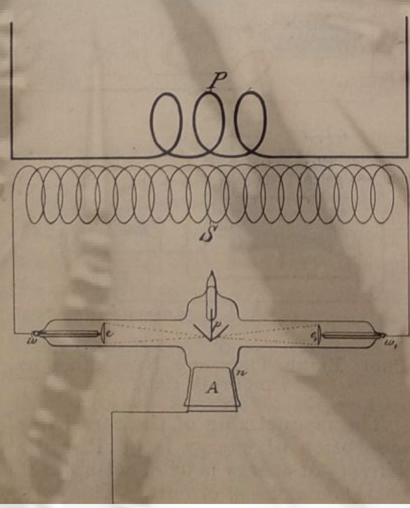


G AN EXPERIMENT
EAL SOURCE OF THE

ion of the stream
ble of producing
phenomena as an
de, it appeared
ow that there is
n of the particles
or otherwise that
upposed streams,
they might be,
onounced in the
to the wall of the
ome of the effects
r to a cathodic
difficult to obtain
ared Lenard tube,
gly thin window,
rprising evidences
Some of these have
ed out, and it is
to cite here one
e since observed.

inside of the bulb, and, what is more, indications were obtained, by observing the shadows, that it behaved like a second source of the rays, inasmuch as the outlines of the shadows, instead of being sharp and clear as when the half-dollar piece was removed, were dimmed. It was immaterial for the chief object of the inquiry to decide by more exact methods whether the cathodic particles actually penetrated the window, or whether a new and separate stream was projected from the outer side of the window. In my mind there exists not the least doubt that the former was the case, as in this respect I have been able to obtain numerous additional proofs, upon which I may dwell in the near future.

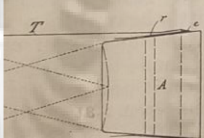
I next endeavored to ascertain whether it was necessary that the obstacle outside was, as in this case, a solid body, or a liquid, or broadly, a body of measurable dimensions, and it was in investigating in this direction that I came upon the important result to which I referred in the introductory statements of this communication. I namely observed rather accidentally, although I was following up a systematic inquiry, what is illustrated in diagram Fig. 1. The diagram shows a Lenard tube of



e and the straight line W were, of course, at once recognized as the outlines of the cathode *e* and the bottom of the cap A respectively, although, in consequence of a confusing optical illusion, they appeared much closer together than they actually were. For instance, if the distance between *e* and *o* was five inches, these lines would appear on the screen about two inches apart, as nearly as I could judge by the eye. This illusion may be easily explained and is quite unimportant, except that it might be of some moment to physicians to keep this fact in mind when making examinations with the screen as, owing to the above effect, which is sometimes exaggerated to a degree hard to believe, a completely erroneous idea of the distance of the various parts of the object under examination might be gained, to the detriment of the surgical operation. But while the lines *e* and W were easily accounted for, the curved lines *t*, *g*, *a* were at first puzzling. Soon, however, it was ascertained that the faint line *a* was the shadow of the edge of the aluminum cap, the much darker line *g* that of the rim of the glass tube T, and *t* the shadow of the tinfoil ring *r*. These shadows on the screen F clearly showed that the agency which affected the fluorescent material was proceeding from the space outside of the bulb towards the aluminum cap, and chiefly from the region through which the primary disturbances or streams emitted from the tube through the window were passing, which observation could not be explained in a more plausible manner than by assuming that the air and dust particles outside, in the path of the projected streams, afforded an obstacle to their passage and gave rise to impacts and collisions spreading through the air in all directions, thus producing continuously new sources of the rays. It is this fact which, in his recent communication

NG AN EXPERIMENT
REAL SOURCE OF THE

ction of the stream
able of producing
phenomena as an
side, it appeared
show that there is
on of the particles
or otherwise that
supposed streams,
e they might be,
ronounced in the
to the wall of the
some of the effects
ar to a cathodic
t difficult to obtain
pared Lenard tube,
ngly thin window,
urprising evidences
Some of these have
ted out, and it is
to cite here one
ve since observed.
minum cap A of a
diagram Fig. 1,
cribed in detail, I
r silver piece, sup-
nall distance from
win low or bottom
trips of mica in
that it was not



ED LENARD TUBE.

al of the tube, an
left all around it.
e bulb for about 30
the secondary dis-
rful coil of a novel
nown, it was found
ece was rendered so
y scorch the hand;
m window, which
significant obstacle
stream, was only
ed. Thus it was
ilver alloy, owing to
thickness, took up
rgy of the impact,
on by the particles
ly as if it had been

direction that I came upon the important result to which I referred in the introductory statements of this communication. I namely observed rather accidentally, although I was following up a systematic inquiry, what is illustrated in diagram Fig. 1. The diagram shows a Lenard tube of

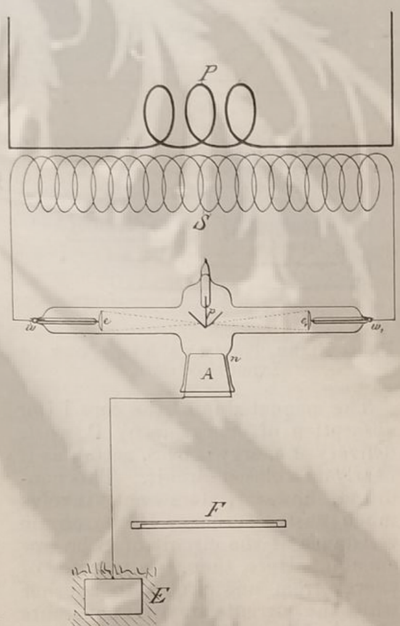


FIG. 3.—ILLUSTRATING ARRANGEMENT WITH IMPROVED DOUBLE-FOCUS TUBE FOR REDUCING THE INJURIOUS ACTIONS.

improved design, consisting of a tube T of thick glass tapering towards the open end, or neck *n*, into which is fitted an aluminum cap A, and a spherical cathode *e*, supported on a glass stem *s*, and platinum wire *w* sealed in the opposite end of the tube as usual. The aluminum cap A, as will be observed, is not in actual contact with the ground-glass wall, being held at a small distance from the latter by a narrow and continuous ring of tinfoil *r*. The outer space between the glass and the cap A is filled with cement *c*, in a manner which I shall later describe. F is a Roentgen screen such as is ordinarily used in making the observations.

Now, in looking upon the screen in the direction from F to T, the dark lines indicated on the lower part of the diagram were seen on the illuminated background. The curved line

however, it was ascertained that the faint line *a* was the shadow of the edge of the aluminum cap, the much darker line *g* that of the rim of the glass tube T, and *t* the shadow of the tinfoil ring *r*. These shadows on the screen F clearly showed that the agency which affected the fluorescent material was proceeding from the space outside of the bulb towards the aluminum cap, and chiefly from the region through which the primary disturbances or streams emitted from the tube through the window were passing, which observation could not be explained in a more plausible manner than by assuming that the air and dust particles outside, in the path of the projected streams, afforded an obstacle to their passage and gave rise to impacts and collisions spreading through the air in all directions, thus producing continuously new sources of the rays. It is this fact which, in his recent communication before mentioned, Roentgen has brought out. So, at least, I have interpreted his reported statement that the rays emanate from the irradiated air. It now remains to be shown whether the air, from which carefully all foreign particles are removed, is capable of behaving as an impact body and source of the rays, in order to decide whether the generation of the latter is dependent on the presence in

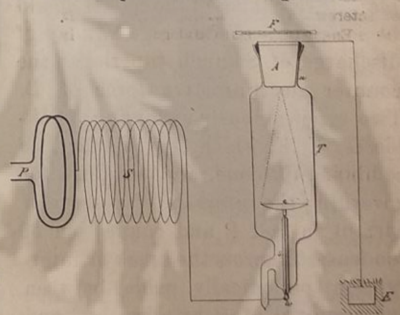


FIG. 4.—ILLUSTRATING ARRANGEMENT WITH A LENARD TUBE FOR SAFE WORKING AT CLOSE RANGE.

the air of impact particles of measurable dimensions. I have reasons to think so.

With the knowledge of this fact we are now able to form a more general

(Concluded on page 71.)

TESLA ON THE SOURCE OF ROENTGEN RAYS AND THE PRACTICAL CONSTRUCTION AND SAFE OPERATION OF LENARD TUBES.

To the Editor of Electrical Review:

I have for some time felt that a few indications in regard to the practical construction of Lenard tubes of improved designs, a great number of which I have recently exhibited before the New York Academy of Sciences (April 6, 1897), would be useful and timely, particularly as by their proper construction and use much of the danger attending the experimentation with the rays may be avoided. The simple precautions which I have suggested in my previous communications to your esteemed journal are seemingly disregarded, and cases of injury to patients are being almost daily reported, and in view of this only, were it for no other reason, the following lines, referring to this subject, would have been written before had not again pressing and unavoidable duties prevented me from doing so. A short and, I may say, most unwelcome interruption of the work which has been claiming my attention makes this now possible. However, as these opportunities are scarce, I will utilize the present to dwell in a few words on some other matters in connection with this subject, and particularly on a result of importance which I have reached some time ago by the aid of such a Lenard tube, and which, if I am correctly informed, I can only in part consider as my own, since it seems that practically it has been expressed in other words by Professor Roentgen in a recent communication to the Academy of Sciences of Berlin. The result alluded to has reference to the much disputed question of the source of the Roentgen rays. As will be remembered, in the first announcement of his discovery, Roentgen was of the opinion that the rays which affected the sensitive layer emanated from the fluorescent spot on the glass wall of the bulb; other scientific men next made the cathode responsible; still others the anode, while some thought that the rays were emitted solely from fluorescent powders or surfaces, and speculations, mostly unfounded, increased to such an extent that, despairingly, one would exclaim with the poet:

"O gluecklich wer noch hoffen kann,
Aus diesem Meer des Irrtums aufzutauchen!"

My own experiments led me to recognize that, regardless of the location, the chief source of these rays was the place of the *first* impact of the projected stream of particles within the bulb. This was merely a broad statement, of which that of Professor Roentgen was a special case, as in his first experiments the fluorescent spot on the glass wall was, incidentally, the place of the first impact of the cathodic stream. Investigations carried on up to the present day have only confirmed the correctness of the above opinion, and the place of the first collision of the stream of particles—be it an anode or independent impact body, the glass wall or an aluminum window—is still found to be the principal source of the rays. But, as will be seen presently, it is not the only source.

Since recording the above fact my efforts were directed to finding answers to the following questions: First, is it necessary that the impact body should be within the tube? Second, is it required that the obstacle in the path of the cathodic stream should be a solid or liquid? And, third, to what extent is the velocity of the stream necessary for the generation of and influence upon the character of the rays emitted?

In order to ascertain whether a body located outside of the tube and in the

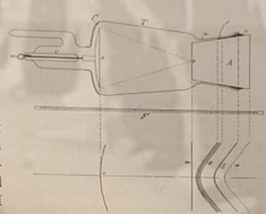


Fig. 1.—Illustrating an Experiment Revealing the Real Source of the Roentgen Rays.

path or in the direction of the stream of particles was capable of producing the same peculiar phenomena as an object located inside, it appeared necessary to first show that there is an actual penetration of the particles through the wall, or otherwise that the actions of the supposed streams, of whatever nature they might be, were sufficiently pronounced in the outer region close to the wall of the bulb as to produce some of the effects which are peculiar to a cathodic stream. It was not difficult to obtain with a properly prepared Lenard tube, having an exceedingly thin window, many and at first surprising evidences of this character. Some of these have already been pointed out, and it is thought sufficient to cite here one more which I have since observed. In the hollow aluminum cap A of a tube as shown in diagram Fig. 1, which will be described in detail, I placed a half-dollar silver piece, supporting it at a small distance from and parallel to the window or bottom of the cap by strips of mica in such a manner that it was not

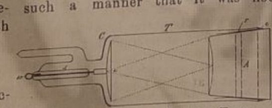


Fig. 2.—Improved Lenard Tube.

touching the metal of the tube, an air space being left all around it. Upon exciting the bulb for about 30 to 45 seconds by the secondary discharge of a powerful coil of a novel type now well known, it was found that the silver piece was rendered so hot as to actually scorch the hand; yet the aluminum window, which offered a very insignificant obstacle to the cathodic stream, was only moderately warmed. Thus it was shown that the silver alloy, owing to its density and thickness, took up most of the energy of the impact, being acted upon by the particles almost identically as if it had been inside of the bulb, and, what is more, indications were obtained, by observing the shadows, that it behaved like a second source of the rays, inasmuch as the outlines of the shadows, instead of being sharp and clear as when the half-dollar piece was removed, were dimmed. It was immaterial for the chief object of the inquiry to decide by more exact methods whether the cathodic particles actually penetrated the window, or whether a new and separate stream was projected from the outer side of the window. In my mind there exists not the least doubt that the former was the case, as in this respect I have been able to obtain numerous additional proofs, upon which I may dwell in the near future.

I next endeavored to ascertain whether it was necessary that the obstacle outside was, as in this case, a solid body, or a liquid, or broadly, a body of measurable dimensions, and it was in investigating in this direction that I came upon the important result to which I referred in the introductory statements of this communication. I namely observed rather accidentally, although I was following up a systematic inquiry, what is illustrated in diagram Fig. 1. The diagram shows a Lenard tube of

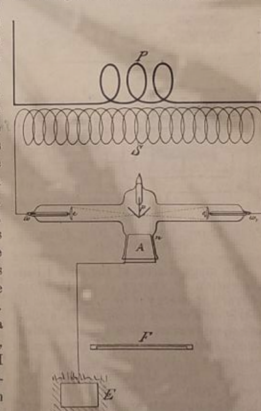


Fig. 3.—Illustrating Arrangement with Improved Double-Focus Tube for Reducing the Injurious Actions.

improved design, consisting of a tube T of thick glass tapering towards the open end, or neck n, into which is fitted an aluminum cap A, and a spherical cathode e, supported on a glass stem s, and platinum wire w sealed in the opposite end of the tube as usual. The aluminum cap A, as will be observed, is not in actual contact with the ground-glass wall, being held at a small distance from the latter by a narrow and continuous ring of tinfoil r. The outer space between the glass and the cap A is filled with cement c, in a manner which I shall later describe. F is a Roentgen screen such as is ordinarily used in making the observations.

Now, in looking upon the screen in the direction from F to T, the dark lines indicated on the lower part of the diagram were seen on the illuminated background. The curved line e and the straight line W were, of course, at once recognized as the outlines of the cathode e and the bottom of the cap A respectively, although, in consequence of a confusing optical illusion, they appeared much closer together than they actually were. For instance, if the distance between e and o was five inches, these lines would appear on the screen about two inches apart, as nearly as I could judge by the eye. This illusion may be easily explained and is quite unimportant, except that it might be of some moment to physicians to keep this fact in mind when making examinations with the screen as, owing to the above effect, which is sometimes exaggerated to a degree hard to believe, a completely erroneous idea of the distance of the various parts of the object under examination might be gained, to the detriment of the surgical operation. But while the lines e and W were easily accounted for, the curved lines t, g, a were at first puzzling. Soon, however, it was ascertained that the faint line a was the shadow of the edge of the aluminum cap, the much darker line g that of the rim of the glass tube T, and t the shadow of the tinfoil ring r. These shadows on the screen F clearly showed that the agency which affected the fluorescent material was proceeding from the space outside of the bulb towards the aluminum cap, and chiefly from the region through which the primary disturbances or streams emitted from the tube through the window were passing, which observation could not be explained in a more plausible manner than by assuming that the air and dust particles outside, in the path of the projected streams, afforded an obstacle to their passage and gave rise to impacts and collisions spreading through the air in all directions, thus producing continuously new sources of the rays. It is this fact which, in his recent communication before mentioned, Roentgen has brought out. So, at least, I have interpreted his reported statement that the rays emanate from the irradiated air. It now remains to be shown whether the air, from which carefully all foreign particles are removed, is capable of behaving as an impact body and source of the rays, in order to decide whether the generation of the latter is dependent on the presence in

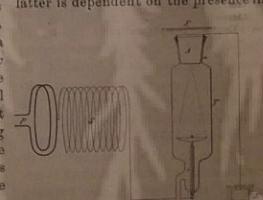


Fig. 4.—Illustrating Arrangement with a Lenard Tube for Safe Working at Close Range.

the air of impact particles of measurable dimensions. I have reasons to think so.

With the knowledge of this fact we are now able to form a more general

(Concluded on page 7[illegible].)

A NEW FORM OF INDUCTION COIL.

READ AT THE FOURTEENTH GENERAL MEETING OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, ELIOT, ME., JULY 26–28, 1897, BY PROF. ELIHU THOMSON.

The induction coil presently to be described, it is believed, constitutes a new type employing the principle of a "substitute primary" or "secondary primary," which principle has been applied by me in a variety of ways.

The prime object of this coil is to permit the direct connection to circuits of considerable potential for obtaining energy for the production of high-potential discharges, like those of a Ruhmkorff coil for working Roentgen-ray vacuum tubes, and for such like purposes. The object, also, was to avoid the employment of banks of lamps or storage batteries, and to limit the energy consumed to only that amount required to work the coil itself. Furthermore, no larger condensers than those ordinarily used with an induction coil of equal capacity are needed, and no air-blast, while the coil as a whole is still available as an ordinary Ruhmkorff without change in its structure or connections.

To illustrate the principle, reference is made to Fig. 1, where *p n* represent connections to mains at, say, 110 volts difference of potential; I I is an iron wire core around which are wound two coils, one over the other, either of which may, of course, be the primary. The inner coil P in the figure is made the primary, and is wound with many turns of comparatively fine wire. For 110 volts it may have some thousands of turns and be wound with a wire safe for .5 to .75 ampere. The outside wire S may be coarse or fine. In the figure it is quite coarse and of relatively few turns, since it is assumed to give low potential and large current. The coil S is so proportioned as to be practically almost short-circuited at intervals by its load at B, which is three cells of storage battery in series, for example. The object is assumed to be that the batteries are charged by transference of energy from coil P to S at low potential in S. The coil S should have ample copper so as to lower its internal resistance as much as possible; the resistance of the cells B should be low; and the average voltage of discharge of S much superior to the counter electro-motive force of B. Two synchronously revolving break-pieces, E, F, which may, in fact, be combined into one, are used; E is for governing the intervals of passage of current in coil P and connection of condenser C across the break or interruption periodically made between one terminal of P by a brush G and a metallic segment on E occupying a considerable arc on its periphery. Brush H connects to main *n*. Back of the main segment on E is a small condenser segment in continuous connection with one side or foil of the condenser, and the other side is connected to the other terminal of P, or that leading direct from line *p*. The contact maker and breaker F has a segment which is in continuous connection with one terminal of battery B to be charged, and which touches a stationary brush J, at or about the time of the break between brush G on the main segment of E. The battery B may have terminals by which it may furnish current while being charged.

Now let the break-wheels E and F be given rapid revolution, say, 10, 20 or 30 per second. The contact of brushes G and H with the main segment of E passes current for a certain considerable fraction of the revolution, at full line potential of 110 volts, through primary P. The current rises gradually during this period, and may at the end attain a value of one ampere, more or less. With slow revolution it would be limited by the resistance of P chiefly, but at rapid rates, the time constant of P acting as a self-induction, determines the ultimate value of current before breaking. Upon the break of brush G with the main segment it touches the condenser segment, which is thereby put across the break; but the circuit of S is also closed by contact of segment on F with brush J. The condenser receives only a small charge on account of the circuit of S having been closed. In fact, the break at G with main segment of E would be nearly sparkless without the condenser C, but what slight self-induction is not wiped out by the mutual induction of the currents in S and P is very easily taken care of.

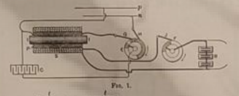


Fig. 1.

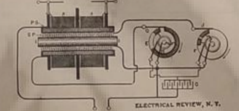


Fig 2.

Prof. Elihu Thomson's New Form of Induction Coil.

The magnetizing of the core I I or absorption of energy is by P, while delivery of energy is by S, acting as if nearly on a closed circuit. This condition, however, does not involve much waste of energy if the ohmic resistance of the circuit of S be low enough. Here, then, is a transfer of energy from one circuit to another while the currents are direct currents in each circuit. To insure this being the case in S, the time of contact of segment on F with brush J must be selected so as not to permit any reversal; i. e., the break of said segment with K must be timed to be made on the cessation of the first impulse or discharge from S. To do this an ammeter, responding to direct currents only, placed in the battery circuit or in the leads from S, will indicate a maximum direct current when the segment F is of proper extent, and less under other conditions.

With the principles of the above apparatus in mind it is easy to understand the action of my new form of induction coil, which may be described, briefly, as follows: The iron core I, Fig. 2, of the induction coil is wound with the ordinary coarse primary coil and terminals provided therefor. Then a coil of intermediate gauge, between the inner primary and the outer secondary, is wound. It is to be capable of being connected across a circuit of 110 volts as with coil P, Fig. 1. This coil is the true primary or energy supplying coil, but for convenience and saving of wire I prefer to connect it in as the under portion of the real secondary circuit. It thus becomes useful as a part of the secondary itself, and having several thousand turns adds a considerable fraction to the total potential of the secondary. The secondary is, as usual, of quite fine wire of many thousands of turns, well insulated throughout.

In Fig. 2 the coarse coil is marked S P, and the intermediate coil P S, while that outside is marked S. The functions of the coils S P and P S are to act as secondaries and primaries alternately. This is, in fact, an essential function of S P, but is only incidental to coil P S, having been connected into the secondary circuit S, whose terminals are at *t t*. The break-wheels E F are like those of Fig. 1, except that in F there is a much shorter main segment and a condenser segment following, as in E. There is no battery in the circuit of S P, but it is put on dead short-circuit at intervals, just at the time P S is broken. Coil P S receives current from line at *p n*, at 100 to 200 volts, or more. On the break of this circuit at brush G the ampere turns, so to speak, are shifted suddenly into circuit of S P, closed on itself by J F. The consequence is that even at slow breaks no spark occurs at the rupture of G E. As soon as the current has been fully established in S P on short circuit, and after brush Q has got entirely away from all metallic connections on E, the main segment of F breaks the circuit of S P, which is conveying a very heavy current at low potential. The condenser C is put instantly across the break, and the spark flies between terminals *t t*. In this way a coil of the size of a six-inch Ruhmkorff gives a torrent of six-inch sparks, with an average current from a 110-volt line of about one-half an ampere. A simple motor or clock-work may be used to drive the break-wheels E F, which are made of fair diameter to insure accuracy in operation. The best results are only to be obtained when the proportioning of the parts is carefully done, and with a knowledge of the result to be obtained.

The discharges are indistinguishable from those of a similar Ruhmkorff. In fact, the coil described might be used with the same condenser C as an ordinary Ruhmkorff coil energized by batteries. In this case the terminals of the coil section P S are disconnected, brush J lifted and battery inserted between brush G and terminal of S P, which goes to J in Fig. 2. The break-wheel E or F, when run with low potentials, may be immersed in water in the usual way to facilitate sharp breaks, but the apparatus has been very successfully run, at full output, dry, or a little heavy oil on the break suffices. Also, the flux of current in S P may be made by a magnet to break its own circuit under water when the current has risen to a predetermined amount. In other words, it may be provided with the usual automatic break, damped or adjusted not to get into tremulous vibration. It will be seen from the above description that a new way of energizing an induction coil or other transforming apparatus has been embodied, and that it consists in the rapid substitution of secondary and primary functions in the coil S P.

John H. and Harry L. Lamson have commenced a suit against the Akron, Bedford & Cleveland, Ohio, Electric Railroad Company, to compel appropriation of alleged property rights. The plaintiffs say that they own 2,000 feet of land on the line of the railway, and they want money for their rights in the street, which they claim have been usurped by the railway company.

ELECTRIC RAILWAY NOTES.

McKinzie, Flint & Winsby have levied an attachment on all the stock of the Citizens' Traction Company, of San Diego, Cal., owned by G. B. Kerper and C. W. Foote, to secure payment of an alleged debt of $607.20.

A trust mortgage for $552,000 from the Falls Road Electric Railway Company, of Baltimore, to the Maryland Trust Company, to secure the issue of an equal amount of bonds, has been recorded. The bonds will run for 50 years and will bear five per cent interest.

The Milwaukee, Wis., Electric Railway and Light Company has completed negotiations for the purchase of the property of the Waukesha Beach Electric Railway Company, consisting principally of the tracks, right of way, etc., from Waukesha to Pewaukee Lake.

The Waukesha, Wis., Electric Railway Company, Stutley I. Henderson, stockholder, has petitioned for the appointment of a receiver to wind up the affairs of the company, which was capitalized at $3,000,000. The company was incorporated a year ago, but only enough of the road was built to protect the franchise.

The Board of Public Works is considering a proposition of the Milwaukee, Wis., Electric Railway and Light Company for burying its feed wires along Grand avenue, except along the block between Tenth and Eleventh streets, where they are to remain overhead, because of the board's refusal to tear up the asphalt pavement.

The Postal Telegraph Company, of Portland, Me., has brought suit in the United States Circuit Court against the Portland & Yarmouth Railroad Company. The case arises out of the setting of the trolley poles of the Yarmouth road, the Postal Telegraph Company claiming that the trolley wires have been placed so near to the telegraph wires as to make the latter nearly useless for the transmission of messages.

Mrs. Luther Lane has brought an odd suit against the Cleveland, Ohio, Electric Railway Company. She claims damages for two separate causes of action, but both of them involve the same state of facts, except that they occurred several years apart. The first cause arose April 18, 1894. Plaintiff charges that she was on one of the defendant's cars and wished to alight at the corner of Dunham and Lexington avenues. She says that the car was started before she could get off, and that she was thrown to the ground, injuring her arm, shoulder and hip, and suffering great nervous shock from her fall. For this she claims $2,500. May 24, 1897, at the same corner, in one of defendant's cars, she charges that she was again thrown down in the same way, and injured the same shoulder, arm and hip. Damages in this case are laid at $3,000. She charges that her injuries were so severe that she has not been able to attend to her duties as a housewife since.

A NEW FORM OF INDUCTION COIL.

READ AT THE FOURTEENTH GENERAL MEETING OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, ELIOT, ME., JULY 26–28, 1897, BY PROF. ELIHU THOMSON.

The induction coil presently to be described, it is believed, constitutes a new type employing the principle of a "substitute primary" or "secondary primary," which principle has been applied by me in a variety of ways.

The prime object of this coil is to permit the direct connection to circuits of considerable potential for obtaining energy for the production of high-potential discharges, like those of a Ruhmkorff coil for working Roentgen-ray vacuum tubes, and for such like purposes. The object, also, was to avoid the employment of banks of lamps or storage batteries, and to limit the energy consumed to only that amount required to work the coil itself. Furthermore, no larger condensers than those ordinarily used with an induction coil of equal capacity are needed, and no air-blast, while the coil as a whole is still available as an ordinary Ruhmkorff without change in its structure or connections.

To illustrate the principle, reference is made to Fig. 1, where $p\ n$ represent connections to mains at, say, 110 volts difference of potential; I I is an iron wire core around which are wound two coils, one over the other, either of which may, of course, be the primary. The inner coil P in the figure is made the primary, and is wound with many turns of comparatively fine wire. For 110 volts it may have some thousands of turns and be wound with a wire safe for .5 to .75 ampere. The outside wire S may be coarse or fine. In the figure it is quite coarse and of relatively few turns,

tion with one terminal of battery B to be charged, and which touches a stationary brush J, at or about the time of the break between brush G on the main segment of E. The battery B may have terminals by which it may furnish current while being charged.

Now let the break-wheels E and F be given rapid revolution, say, 10, 20 or 30 per second. The contact of brushes G and H with the main segment of E passes current for a certain considerable fraction of the revolution, at full line potential of 110 volts, through primary P. The current rises gradually during this period, and may at the end attain a value of one ampere, more or less. With slow revolution it would be limited by the resistance of P chiefly, but at rapid rates, the time constant of P acting as a self-induction, determines the ultimate value of current before breaking. Upon the break of brush G with the main segment it touches the condenser segment, which is thereby put across the break; but the circuit of S is also closed by contact of segment on F with brush J. The condenser receives only a small charge on account of the circuit of S having been closed. In fact, the break at G with main segment of E would be nearly sparkless without the condenser C, but what slight self-induction is not wiped out by the mutual induction of the currents in S and P is very easily taken care of.

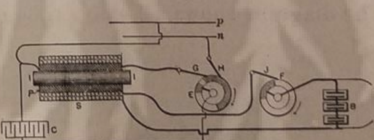


Fig. 1.

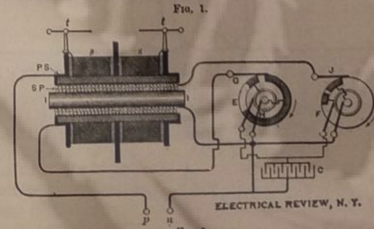


Fig. 2.

PROF. ELIHU THOMSON'S NEW FORM OF INDUCTION COIL.

The magnetizing of the core I I or absorption of energy is by P, while delivery of energy is by S, acting as if

secondary circuit.
useful as a part
itself, and having
turns adds a consi
the total potential
The secondary is,
fine wire of many
well insulated thro

In Fig. 2 th
marked S P, and
coil P S, whil
marked S. The
coils S P and P
ondaries and pri
This is, in fact, a
of S P, but is onl
P S, having been
secondary circuit
are at $t\ t$. The b
like those of Fig.
there is a much sh
and a condenser
as in E. There i
circuit of S P, bu
short-circuit at i
time P S is broken
current from line
volts, or more. (
circuit at brush G
so to speak, are sl
circuit of S P, clo
The consequence
breaks no spark o
of G E. As so
has been fully es
short circuit, and
got entirely away
connections on E
of F breaks the c
is conveying a ve
low potential. T
put instantly acr
the spark flies be
In this way a coil
inch Ruhmkorff
six-inch sparks, w
rent from a 110
one-half an amper
or clock-work ma
the break-wheels
made of fair diam
racy in operation
are only to be obt
portioning of the
done, and with
result to be obtain

The discharges
able from those
korff. In fact,
might be used w
denser C as an o

obtaining energy for the production of high-potential discharges, like those of a Ruhmkorff coil for working Roentgen-ray vacuum tubes, and for such like purposes. The object, also, was to avoid the employment of banks of lamps or storage batteries, and to limit the energy consumed to only that amount required to work the coil itself. Furthermore, no larger condensers than those ordinarily used with an induction coil of equal capacity are needed, and no air-blast, while the coil as a whole is still available as an ordinary Ruhmkorff without change in its structure or connections.

To illustrate the principle, reference is made to Fig. 1, where *p n* represent connections to mains at, say, 110 volts difference of potential; I I is an iron wire core around which are wound two coils, one over the other, either of which may, of course, be the primary. The inner coil P in the figure is made the primary, and is wound with many turns of comparatively fine wire. For 110 volts it may have some thousands of turns and be wound with a wire safe for .5 to .75 ampere. The outside wire S may be coarse or fine. In the figure it is quite coarse and of relatively few turns, since it is assumed to give low potential and large current. The coil S is so proportioned as to be practically almost short-circuited at intervals by its load at B, which is three cells of storage battery in series, for example. The object is assumed to be that the batteries are charged by transference of energy from coil P to S at low potential in S. The coil S should have ample copper so as to lower its internal resistance as much as possible; the resistance of the cells B should be low; and the average voltage of discharge of S much superior to the counter electro-motive force of B. Two synchronously revolving break-pieces, E, F, which may, in fact, be combined into one, are used; E is for governing the intervals of passage of current in coil P and connection of condenser C across the break or interruption periodically made between one terminal of P by a brush G and a metallic segment on E occupying a considerable arc on its periphery. Brush H connects to main *n*. Back of the main segment on E is a small condenser segment in continuous connection with one side or foil of the condenser, and the other side is connected to the other terminal of P, or that leading direct from line *p*. The contact maker and breaker F has a segment which is in continuous connec-

resistance of P chiefly, but at rapid rates, the time constant of P acting as a self-induction, determines the ultimate value of current before breaking. Upon the break of brush G with the main segment it touches the condenser segment, which is thereby put across the break; but the circuit of S is also closed by contact of segment on F with brush J. The condenser receives only a small charge on account of the circuit of S having been closed. In fact, the break at G with main segment of E would be nearly sparkless without the condenser C, but what slight self-induction is not wiped out by the mutual induction of the currents in S and P is very easily taken care of.

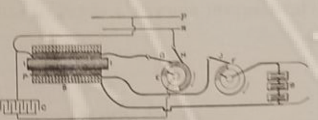


FIG. 1.

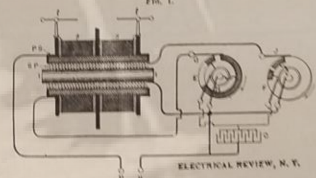


FIG. 2.

PROF. ELIHU THOMSON'S NEW FORM OF INDUCTION COIL.

The magnetizing of the core I I or absorption of energy is by P, while delivery of energy is by S, acting as if nearly on a closed circuit. This condition, however, does not involve much waste of energy if the ohmic resistance of the circuit of S be low enough. Here, then, is a transfer of energy from one circuit to another while the currents are direct currents in each circuit. To insure this being the case in S, the time of contact of segment on F with brush J must be selected so as not to permit any reversal; i. e., the break of said segment with K must be timed to be made on the cessation of the first impulse or discharge from S. To do this an ammeter, responding to direct currents only, placed in the battery circuit or in the leads from S, will indicate a maximum direct current when the segment F is of proper extent, and less under other conditions.

With the principles of the above apparatus in mind it is easy to understand the action of my new form of induction coil, which may be described, briefly, as follows: The iron core I, Fig. 2, of the induction coil is wound with the ordinary coarse primary coil and terminals provided therefor. Then a coil of intermediate gauge, between the inner primary and the outer secondary, is wound. It is to be capable of being connected across a circuit of 110 volts as with coil P, Fig. 1. This coil is the true primary or energy supplying coil, but for convenience and saving of wire I prefer to connect it in as the under portion of the real

and a condenser segment follo
as in E. There is no battery in
circuit of S P, but it is put on de
short-circuit at intervals, just at t
time P S is broken. Coil P S recei
current from line at *p n*, at 100 to
volts, or more. On the break of t
circuit at brush G the ampere tur
so to speak, are shifted suddenly in
circuit of S P, closed on itself by J
The consequence is that even at sl
breaks no spark occurs at the ruptu
of G E. As soon as the curre
has been fully established in S P
short circuit, and after brush Q h
got entirely away from all metal
connections on E, the main segme
of F breaks the circuit of S P, whi
is conveying a very heavy current
low potential. The condenser C
put instantly across the break, a
the spark flies between terminals
In this way a coil of the size of a s
inch Ruhmkorff gives a torrent
six-inch sparks, with an average c
rent from a 110-volt line of ab
one-half an ampere. A simple mo
or clock-work may be used to dr
the break-wheels E F, which
made of fair diameter to insure ac
racy in operation. The best resu
are only to be obtained when the p
portioning of the parts is carefu
done, and with a knowledge of
result to be obtained.

The discharges are indistingui
able from those of a similar Ruh
korff. In fact, the coil descri
might be used with the same c
denser C as an ordinary Ruhmk
coil energized by batteries. In t
case the terminals of the coil sect
P S are disconnected, brush J lif
and battery inserted between br
G and terminal of S P, which goe
J in Fig. 2. The break-wheel E
F, when run with low potentials, r
be immersed in water in the us
way to facilitate sharp breaks,
the apparatus has been very succ
fully run, at full output, dry, c
little heavy oil on the break suffi
Also, the flux of current in S P r
be made by a magnet to break its c
circuit under water when the curr
has risen to a predetermined amou
In other words, it may be provi
with the usual automatic bre
damped or adjusted not to get i
tremulous vibration. It will be s
from the above description that a
way of energizing an induction
or other transforming apparatus
been embodied, and that it cons
in the rapid substitution of second
and primary functions in the coil S

John H. and Harry L. Lamson h
commenced a suit against the Akr
Bedford & Cleveland, Ohio, Elec
Railroad Company, to compel app
priation of alleged property rig
The plaintiffs say that they own 2,
feet of land on the line of the railw
and they want money for their rig
in the street, which they claim h
been usurped by the railway compa

one terminal of battery B
ged, and which touches a
brush J, at or about the
e break between brush G
ain segment of E. The
may have terminals by
nay furnish current while
ged.
the break-wheels E and F
pid revolution, say, 10, 20
second. The contact of
and H with the main seg-
passes current for a certain
le fraction of the revolu-
ll line potential of 110
ugh primary P. The cur-
radually during this period,
the end attain a value of
, more or less. With slow
it would be limited by the
of P chiefly, but at rapid
ime constant of P acting
f - induction, determines
ate value of current
king. Upon the break of
ith the main segment it
condenser segment, which
put across the break; but
of S is also closed by con-
ment on F with brush J.
nser receives only a small
ccount of the circuit of S
closed. In fact, the break
main segment of E would
parkless without the con-
ut what slight self-induc-
wiped out by the mutual
f the currents in S and P
y taken care of.

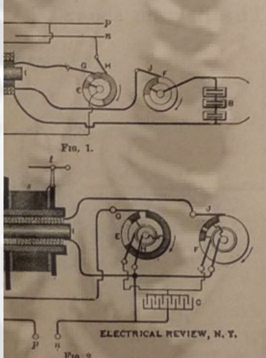


Fig. 1.

ELECTRICAL REVIEW, N. Y.

Fig. 2.

THOMSON'S NEW FORM OF INDUCTION COIL.

netizing of the core I I or
of energy is by P, while
energy is by S, acting as if
closed circuit. This con-
wever, does not involve

secondary circuit. It thus becomes useful as a part of the secondary itself, and having several thousand turns adds a considerable fraction to the total potential of the secondary. The secondary is, as usual, of quite fine wire of many thousands of turns, well insulated throughout.

In Fig. 2 the coarse coil is marked S P, and the intermediate coil P S, while that outside is marked S. The functions of the coils S P and P S are to act as secondaries and primaries alternately. This is, in fact, an essential function of S P, but is only incidental to coil P S, having been connected into the secondary circuit S, whose terminals are at $t\ t$. The break-wheels E F are like those of Fig. 1, except that in F there is a much shorter main segment and a condenser segment following, as in E. There is no battery in the circuit of S P, but it is put on dead short-circuit at intervals, just at the time P S is broken. Coil P S receives current from line at $p\ n$, at 100 to 200 volts, or more. On the break of this circuit at brush G the ampere turns, so to speak, are shifted suddenly into circuit of S P, closed on itself by J F. The consequence is that even at slow breaks no spark occurs at the rupture of G E. As soon as the current has been fully established in S P on short circuit, and after brush Q has got entirely away from all metallic connections on E, the main segment of F breaks the circuit of S P, which is conveying a very heavy current at low potential. The condenser C is put instantly across the break, and the spark flies between terminals $t\ t$. In this way a coil of the size of a six-inch Ruhmkorff gives a torrent of six-inch sparks, with an average current from a 110-volt line of about one-half an ampere. A simple motor or clock-work may be used to drive the break-wheels E F, which are made of fair diameter to insure accuracy in operation. The best results are only to be obtained when the proportioning of the parts is carefully done, and with a knowledge of the result to be obtained.

The discharges are indistinguishable from those of a similar Ruhmkorff. In fact, the coil described might be used with the same condenser C as an ordinary Ruhmkorff coil energized by batteries. In this case the terminals of the coil secti-

ELECTRIC RAILWAY NOTES.

McKinzie, Flint & Winsby have levied an attachment on all the stock of the Citizens' Traction Company, of San Diego, Cal., owned by G. B. Kerper and C. W. Foote, to secure payment of an alleged debt of $607.20.

A trust mortgage for $552,000 from the Falls Road Electric Railway Company, of Baltimore, to the Maryland Trust Company, to secure the issue of an equal amount of bonds, has been recorded. The bonds will run for 50 years and will bear five per cent interest.

The Milwaukee, Wis., Electric Railway and Light Company has completed negotiations for the purchase of the property of the Waukesha Beach Electric Railway Company, consisting principally of the tracks, right of way, etc., from Waukesha to Pewaukee Lake.

The Waukesha, Wis., Electric Railway Company, Stutley I. Henderson, stockholder, has petitioned for the appointment of a receiver to wind up the affairs of the company, which was capitalized at $3,000,000. The company was incorporated a year ago, but only enough of the road was built to protect the franchise.

The Board of Public Works is considering a proposition of the Milwaukee, Wis., Electric Railway and Light Company for burying its feed wires along Grand avenue, except along the block between Tenth and Eleventh streets, where they are to remain overhead, because of the board's refusal to tear up the asphalt pavement.

The Postal Telegraph Company, of Portland, Me., has brought suit in the United States Circuit Court against the Portland & Yarmouth Railroad Company. The case arises out of the setting of the trolley poles of the Yarmouth road, the Postal Telegraph

er receives only a small
count of the circuit of S
losed. In fact, the break
ain segment of E would
arkless without the con-
t what slight self-induc-
riped out by the mutual
the currents in S and P
taken care of.

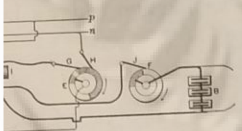


Fig. 1.

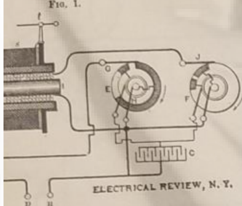


Fig. 2.

THOMSON'S NEW FORM OF
INDUCTION COIL.

netizing of the core I I or
of energy is by P, while
energy is by S, acting as if
closed circuit. This con-
vever, does not involve
e of energy if the ohmic
of the circuit of S be low
Here, then, is a transfer of
n one circuit to another
urrents are direct currents
uit. To insure this being
S, the time of contact of
F with brush J must be
as not to permit any re-
., the break of said segment
ist be timed to be made on
on of the first impulse or
from S. To do this an
responding to direct cur-
, placed in the battery cir-
the leads from S, will indi-
ximum direct current when
nt F is of proper extent,
nder other conditions.
he principles of the above
in mind it is easy to under-
action of my new form of
coil, which may be de-
briefly, as follows: The
I, Fig. 2, of the induction
und with the ordinary coarse
coil and terminals provided
Then a coil of interme-
ge, between the inner pri-
d the outer secondary, is
It is to be capable of being
d across a circuit of 110
with coil P, Fig. 1. This
he true primary or energy
g coil, but for convenience
ng of wire I prefer to connect
the under portion of the real

circuit ... The consequence is that even at the rupture breaks no spark occurs at the rupture of G E. As soon as the current has been fully established in S P on short circuit, and after brush Q has got entirely away from all metallic connections on E, the main segment of F breaks the circuit of S P, which is conveying a very heavy current at low potential. The condenser C is put instantly across the break, and the spark flies between terminals *t t*. In this way a coil of the size of a six-inch Ruhmkorff gives a torrent of six-inch sparks, with an average current from a 110-volt line of about one-half an ampere. A simple motor or clock-work may be used to drive the break-wheels E F, which are made of fair diameter to insure accuracy in operation. The best results are only to be obtained when the proportioning of the parts is carefully done, and with a knowledge of the result to be obtained.

The discharges are indistinguishable from those of a similar Ruhmkorff. In fact, the coil described might be used with the same condenser C as an ordinary Ruhmkorff coil energized by batteries. In this case the terminals of the coil section P S are disconnected, brush J lifted and battery inserted between brush G and terminal of S P, which goes to J in Fig. 2. The break-wheel E or F, when run with low potentials, may be immersed in water in the usual way to facilitate sharp breaks, but the apparatus has been very successfully run, at full output, dry, or a little heavy oil on the break suffices. Also, the flux of current in S P may be made by a magnet to break its own circuit under water when the current has risen to a predetermined amount. In other words, it may be provided with the usual automatic break, damped or adjusted not to get into tremulous vibration. It will be seen from the above description that a new way of energizing an induction coil or other transforming apparatus has been embodied, and that it consists in the rapid substitution of secondary and primary functions in the coil S P.

John H. and Harry L. Lamson have commenced a suit against the Akron, Bedford & Cleveland, Ohio, Electric Railroad Company, to compel appropriation of alleged property rights. The plaintiffs say that they own 2,000 feet of land on the line of the railway, and they want money for their rights in the street, which they claim have been usurped by the railway company.

stockholder, has ... appointment of a receiver to wind up the affairs of the company, which was capitalized at $3,000,000. The company was incorporated a year ago, but only enough of the road was built to protect the franchise.

The Board of Public Works is considering a proposition of the Milwaukee, Wis., Electric Railway and Light Company for burying its feed wires along Grand avenue, except along the block between Tenth and Eleventh streets, where they are to remain overhead, because of the board's refusal to tear up the asphalt pavement.

The Postal Telegraph Company, of Portland, Me., has brought suit in the United States Circuit Court against the Portland & Yarmouth Railroad Company. The case arises out of the setting of the trolley poles of the Yarmouth road, the Postal Telegraph Company claiming that the trolley wires have been placed so near to the telegraph wires as to make the latter nearly useless for the transmission of messages.

Mrs. Luther Lane has brought an odd suit against the Cleveland, Ohio, Electric Railway Company. She claims damages for two separate causes of action, but both of them involve the same state of facts, except that they occurred several years apart. The first cause arose April 18, 1894. Plaintiff charges that she was on one of the defendant's cars and wished to alight at the corner of Dunham and Lexington avenues. She says that the car was started before she could get off, and that she was thrown to the ground, injuring her arm, shoulder and hip, and suffering great nervous shock from her fall. For this she claims $2,500. May 24, 1897, at the same corner, in one of defendant's cars, she charges that she was again thrown down in the same way, and injured the same shoulder, arm and hip. Damages in this case are laid at $3,000. She charges that her injuries were so severe that she has not been able to attend to her duties as a housewife since.

charge on account of the circuit of S having been closed. In fact, the break at G with main segment of E would be nearly sparkless without the condenser C, but what slight self-induction is not wiped out by the mutual induction of the currents in S and P is very easily taken care of.

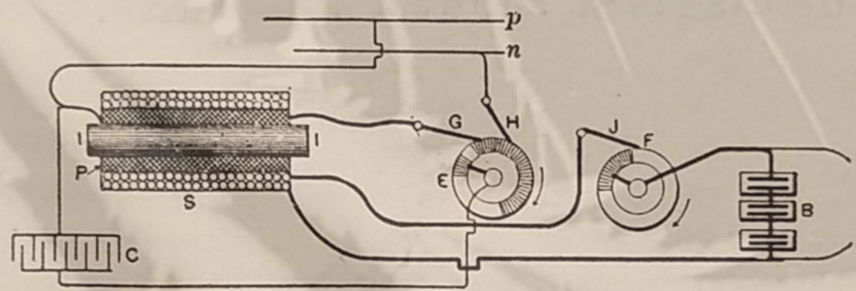


Fig. 1.

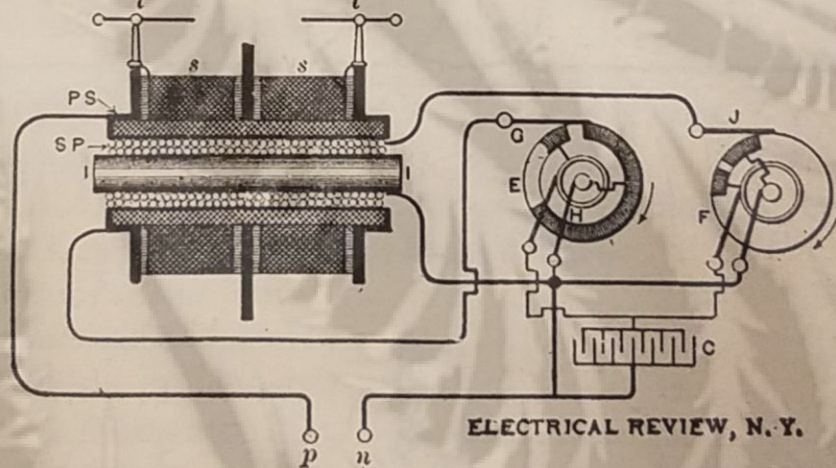


Fig. 2.

Prof. Elihu Thomson's New Form of Induction Coil.

The magnetizing of the core I I or absorption of energy is by P, while delivery of energy is by S, acting as if nearly on a closed circuit. This con-

TESLA ON ROENTGEN RAYS.

(Concluded from page 67.)

idea of the process of generation of the radiations which have been discovered by Lenard and Roentgen. It may be comprised in the statement that the streams of minute material particles projected from an electrode with great velocity in encountering obstacles wherever they may be, within the bulb, in the air or other medium or in the sensitive layers themselves, give rise to rays or radiations possessing many of the properties of those known as light. If this physical process of generation of these rays is undoubtedly demonstrated as true, it will have most important consequences, as it will induce physicists to again critically examine many phenomena which are presently attributed to transverse ether waves, which may lead to a radical modification of existing views and theories in regard to these phenomena, if not as to their essence so, at least, as to the mode of their production.

My effort to arrive at an answer to the third of the above questions led me to the establishment, by actual photographs, of the close relationship which exists between the Lenard and Roentgen rays. The photographs bearing on this point were exhibited at a meeting of the New York Academy of Sciences—before referred to—April 6, 1897, but, unfortunately, owing to the shortness of my address, and concentration of thought on other matters, I omitted what was most important; namely, to describe the manner in which these photographs were obtained, an oversight which I was able to only partially repair the day following. I did, however, on that occasion illustrate and describe experiments in which was shown the deflectibility of the Roentgen rays by a magnet, which establishes a still closer relationship, if not identity, of the rays named after these two discoverers. But the description of these experiments in detail, as well as of other investigations and results in harmony with and restricted to the subject I brought before that scientific body, will appear in a longer communication which I am slowly preparing.

To bring out clearly the significance of the photographs in question, I would recall that, in some of my previous contributions to scientific societies, I have endeavored to dispel a popular opinion before existing that the phenomena known as those of Crookes were dependent on and indicative of high vacua. With this object in view, I showed that phosphorescence and most of the phenomena in Crookes bulbs were producible at greater pressures of the gases in the bulbs by the use of much higher or more sudden electro-motive impulses. Having this well demonstrated fact before me, I prepared a tube in the manner described by Lenard in his first classical communication on this subject. The tube was exhausted to a moderate degree, either by chance or of necessity, and it was found that, when operated by an ordinary high-tension coil of a low rate of change in the current, no rays of any of the two kinds could be detected, even when the tube was so highly strained as to become very hot in a few moments. Now, I expected that, if the suddenness of the impulses through the bulb were sufficiently increased, rays would be emitted. To test this I employed a coil of a type which I have repeatedly described, in which the primary is operated by the discharges of a condenser. With such an instrument any desired suddenness of the impulses may be secured, there being practically no limit in this respect, as the energy accumulated in the condenser is the most violently explosive agent we know, and any potential or electrical pressure is obtainable. Indeed, I found that in increasing the suddenness of the electro motive impulses through the tube—without, however, increasing, but rather diminishing the total energy conveyed to it—phosphorescence was observed and rays began to appear, first the feebler Lenard rays and later, by pushing the suddenness far enough, Roentgen rays of great intensity, which enabled me to obtain photographs showing the finest texture of the bones. Still, the same tube, when again operated with the ordinary coil of a low rate of change in the primary current, emitted practically no rays, even when, as before stated, much more energy, as judged from the heating, was passed through it. This experience, together with the fact that I have succeeded in producing by the use of immense electrical pressures, obtainable with certain apparatus designed for this express purpose, some impressions in free air, have led me to the conclusion that in lightning discharges Lenard and Roentgen rays must be generated at ordinary atmospheric pressure.

At this juncture I realize, by a perusal of the preceding lines, that my scientific interest has dominated the practical, and that the following remarks must be devoted to the primary object of this communication—that is, to giving some data for the construction to those engaged in the manufacture of the tubes and, perhaps, a few useful hints to practicing physicians who are dependent on such information. The foregoing was, nevertheless, not lost for this object, inasmuch as it has shown how much the result obtained depends on the proper construction of the instruments, for, with ordinary implements, most of the above observations could not have been made.

I have already described the form of tube illustrated in Fig. 1, and in Fig. 2 another still further improved design is shown. In this case the aluminum cap A, instead of having a straight bottom as before, is shaped spherically, the center of the sphere coinciding with that of the electrode *e*, which itself, as in Fig. 1, has its focus in the center of the window of cap A, as indicated by the dotted lines. The aluminum cap A has a tinfoil ring *r*, as that in Fig. 1, or else the metal of the cap is spun out on that place so as to afford a bearing of small surface between the metal and the glass. This is an important practical detail as, by making the bearing surface small, the pressure per unit of area is increased and a more perfect joint made. The ring *r* should be first spun out and then ground to fit the neck of the bulb. If a tinfoil ring is used instead, it may be cut out of one of the ordinary tinfoil caps obtainable in the market, care being taken that the ring is very smooth.

In Fig. 3 I have shown a modified design of tube which, as the two types before described, was comprised in the collection I exhibited. This, as will be observed, is a double-focus tube, with impact plates of iridium alloy and an aluminum cap A opposite the same. The tube is not shown because of any originality in design, but simply to illustrate a practical feature. It will be noted that the aluminum caps in the tubes described are fitted inside of the necks and not outside, as is frequently done. Long experience has demonstrated that it is practically impossible to maintain a high vacuum in a tube with an outside cap. The only way I have been able to do this in a fair measure is by cooling the cap by a jet of air, for instance, and observing the following precautions: The air jet is first turned on slightly and upon this the tube is excited. The current through the latter, and also the air pressure, are then gradually increased and brought to the normal working condition. Upon completing the experiment the air pressure and current through the tube are both gradually reduced and both so manipulated that no great differences in temperature result between the glass and aluminum cap. If these precautions are not observed the vacuum will be immediately impaired in consequence of the uneven expansion of the glass and metal.

With tubes, as these presently described, it is quite unnecessary to observe this precaution if proper care is taken in their preparation. In inserting the cap the latter is cooled down as low as it is deemed advisable without endangering the glass, and it is then gently pushed in the neck of the tube, taking care that it sets straight.

The two most important operations in the manufacture of such a tube are, however, the thinning down of the aluminum window and the sealing in of the cap. The metal of the latter may be one thirty-second or even one-sixteenth of an inch thick, and in such case the central portion may be thinned down by a countersink tool about one-fourth of an inch in diameter as far as it is possible without tearing the sheet. The further thinning down may then be done by hand with a scraping tool; and, finally, the metal should be gently beaten down so as to surely close the pores which might permit a slow leak. Instead of proceeding in this way I have employed a cap with a hole in the center, which I have closed with a sheet of pure aluminum a few thousandths of an inch thick, riveted to the cap by means of a washer of thick metal, but the results were not quite as satisfactory.

In sealing the cap I have adopted the following procedure: The tube is fastened on the pump in the proper position and exhausted until a permanent condition is reached. The degree of exhaustion is a measure of perfection of the joint. The leak is usually considerable, but this is not so serious a defect as might be thought. Heat is now gradually applied to the tube by means of a gas stove until a temperature up to about the boiling point of sealing wax is reached. The space between the cap and the glass is then filled with sealing wax of good quality; and, when the latter begins to boil, the temperature is reduced to allow its settling in the cavity. The heat is then again increased, and this process of heating and cooling is repeated several times until the entire cavity, upon reduction of the temperature, is found to be filled uniformly with the wax, all bubbles having disappeared. A little more wax is then put on the top and the exhaustion carried on for an hour or so, according to the capacity of the pump, by application of moderate heat much below the melting point of the wax.

A tube prepared in this manner will maintain the vacuum very well, and will last indefinitely. If not used for a few months, it may gradually lose the high vacuum, but it can be quickly worked up. However, if after long use it becomes necessary to clean the tube, this is easily done by gently warming it and taking off the cap. The cleaning may be done first with acid, then with highly diluted alkali, next with distilled water, and finally with pure rectified alcohol.

These tubes, when properly prepared, give impressions much sharper and reveal much more detail than those of ordinary make. It is important for the clearness of the impressions that the electrode should be properly shaped, and that the focus should be exactly in the center of the cap or slightly inside. In fitting in the cap, the distance from the electrode should be measured as exactly as possible. It should also be remarked that the thinner the window, the sharper are the impressions, but it is not advisable to make it too thin, as it is apt to melt in a point on turning on the current.

The above advantages are not the only ones which these tubes offer. They are also better adapted for purposes of examination by surgeons, particularly if used in the peculiar manner illustrated in diagrams Fig. 3 and Fig. 4, which are self-explanatory. It will be seen that in each of these the cap is connected to the ground. This decidedly diminishes the injurious action and enables also to take impressions with very short exposures of a few seconds only at close range, inasmuch as, during the operation of the bulb, one can easily touch the cap without any inconvenience, owing to the ground connection. The arrangement shown in Fig. 4 is particularly advantageous with a form of single terminal, which coil I have described on other occasions and which is diagramatically illustrated, P being the primary and S the secondary. In this instance the high-potential terminal is connected to the electrode, while the cap is grounded. The tube may be placed in the position indicated in the drawing, under the operating table and quite close, or even in contact with the body of the patient, if the impression requires only a few seconds as, for instance, in examining parts of the members. I have taken many impressions with such tubes and have observed no injurious action, but I would advise not to expose for longer than two or three minutes at very short distances. In this respect the experimenter should bear in mind what I have stated in previous communications. At all events it is certain that, in proceeding in the manner described, additional safety is obtained and the process of taking impressions much quickened. To cool the cap, a jet of air may be used, as before stated, or else a small quantity of water may be poured in the cap each time when an impression is taken. The water only slightly impairs the action of the tube, while it maintains the window at a safe temperature. I may add that the tubes are improved by providing back of the electrode a metallic coating C, shown in Fig. 3 and Fig. 4.

NIKOLA TESLA.

New York, August 9.

Electric Light Plant Wanted.

Mr. T. J. Lillard, treasurer of the Elkin Manufacturing Company, of Elkin, Surry County, N. C., manufacturers of cotton yarns, twines, etc., writes to the ELECTRICAL REVIEW, under date of August 7, as follows:

"We want prices and estimates on a 400-light incandescent dynamo, switchboard, wire and everything used, to light the town of Elkin with, say 100 16-candle-power street lights, and for 30 stores and residences with eight lights each.

TESLA ON ROENTGEN RAYS.

(Concluded from page 67.)

idea of the process of generation of the radiations which have been discovered by Lenard and Roentgen. It may be comprised in the statement that the streams of minute material particles projected from an electrode with great velocity in encountering obstacles wherever they may be, within the bulb, in the air or other medium or in the sensitive layers themselves, give rise to rays or radiations possessing many of the properties of those known as light. If this physical process of generation of these rays is undoubtedly demonstrated as true, it will have most important consequences, as it will induce physicists to again critically examine many phenomena which are presently attributed to transverse ether waves, which may lead to a radical modification of existing views and theories in regard to these phenomena, if not as to their essence so, at least, as to the mode of their production.

My effort to arrive at an answer to the third of the above questions led me to the establishment, by actual photographs, of the close relationship which exists between the Lenard and Roentgen rays. The photographs bearing on this point were exhibited at a meeting of the New York Academy of Sciences—before referred to—April 6, 1897, but, unfortunately, owing to the shortness of my address, and concentration of thought on other matters, I omitted what was most important; namely, to describe the manner in which these photographs were obtained, an oversight which I was able to only partially repair the day following. I did, however, on that occasion illustrate and describe experiments, in which was shown the deflectibility of the Roentgen rays by a magnet, which establishes a still closer relationship, if not identity, of the rays named

described, in which the primary is operated by the discharges of a condenser. With such an instrument any desired suddenness of the impulses may be secured, there being practically no limit in this respect, as the energy accumulated in the condenser is the most violently explosive agent we know, and any potential or electrical pressure is obtainable. Indeed, I found that in increasing the suddenness of the electro motive impulses through the tube—without, however, increasing, but rather diminishing the total energy conveyed to it—phosphorescence was observed and rays began to appear, first the feebler Lenard rays and later, by pushing the suddenness far enough, Roentgen rays of great intensity, which enabled me to obtain photographs showing the finest texture of the bones. Still, the same tube, when again operated with the ordinary coil of a low rate of change in the primary current, emitted practically no rays, even when, as before stated, much more energy, as judged from the heating, was passed through it. This experience, together with the fact that I have succeeded in producing by the use of immense electrical pressures, obtainable with certain apparatus designed for this express purpose, some impressions in free air, have led me to the conclusion that in lightning discharges Lenard and Roentgen rays must be generated at ordinary atmospheric pressure.

At this juncture I realize, by a perusal of the preceding lines, that my scientific interest has dominated the practical, and that the following remarks must be devoted to the primary object of this communication—that is, to giving some data for the construction to those engaged in the manufacture of the tubes and, perhaps, a few useful hints to practicing physicians who are dependent on such information. The foregoing was, nevertheless, not lost for this object, inasmuch as it has shown how much the result obtained depends on the proper construction of the instruments, for, with ordinary implements, most of the above observations could

outside,
experienc
is practic
a high va
side cap.
able to
is by co
air, for i
following
is first tu
this the tu
through t
pressure, a
and broug
condition.
periment t
through th
reduced a
that no gre
ture result
aluminum
are not obs
immediatel
of the unev
and metal.

With tub
scribed, it
observe this
is taken in
inserting th
down as low
without end
it is then g
of the tube,
straight.

The two m
in the manu
are, however
the aluminum
ing in of the
latter may b
even one-sixt
and in such c
may be thinn
sink tool abou
in diameter
without tear
further thinn
done by hand
and, finally,
gently beaten
close the pores
slow leak. In
this way I have
a hole in the
closed with a sh
a few thousand
riveted to the
washer of thick

to their essence so, at least, as to the mode of their production.

My effort to arrive at an answer to the third of the above questions led me to the establishment, by actual photographs, of the close relationship which exists between the Lenard and Roentgen rays. The photographs bearing on this point were exhibited at a meeting of the New York Academy of Sciences—before referred to—April 6, 1897, but, unfortunately, owing to the shortness of my address, and concentration of thought on other matters, I omitted what was most important; namely, to describe the manner in which these photographs were obtained, an oversight which I was able to only partially repair the day following. I did, however, on that occasion illustrate and describe experiments, in which was shown the deflectibility of the Roentgen rays by a magnet, which establishes a still closer relationship, if not identity, of the rays named after these two discoverers. But the description of these experiments in detail, as well as of other investigations and results in harmony with and restricted to the subject I brought before that scientific body, will appear in a longer communication which I am slowly preparing.

To bring out clearly the significance of the photographs in question, I would recall that, in some of my previous contributions to scientific societies, I have endeavored to dispel a popular opinion before existing that the phenomena known as those of Crookes were dependent on and indicative of high vacua. With this object in view, I showed that phosphorescence and most of the phenomena in Crookes bulbs were producible at greater pressures of the gases in the bulbs by the use of much higher or more sudden electro-motive impulses. Having this well demonstrated fact before me, I prepared a tube in the manner described by Lenard in his first classical communication on this subject. The tube was exhausted to a moderate degree, either by chance or of necessity, and it was found that, when operated by an ordinary high-tension coil of a low rate of change in the current, no rays of any of the two kinds could be detected, even when the tube was so highly strained as to become very hot in a few moments. Now, I expected that, if the suddenness of the impulses through the bulb were sufficiently increased, rays would be emitted. To test this I employed a coil of a type which I have repeatedly

... was passed through it. This experience, together with the fact that I have succeeded in producing by the use of immense electrical pressures, obtainable with certain apparatus designed for this express purpose, some impressions in free air, have led me to the conclusion that in lightning discharges Lenard and Roentgen rays must be generated at ordinary atmospheric pressure.

At this juncture I realize, by a perusal of the preceding lines, that my scientific interest has dominated the practical, and that the following remarks must be devoted to the primary object of this communication—that is, to giving some data for the construction to those engaged in the manufacture of the tubes and, perhaps, a few useful hints to practicing physicians who are dependent on such information. The foregoing was, nevertheless, not lost for this object, inasmuch as it has shown how much the result obtained depends on the proper construction of the instruments, for, with ordinary implements, most of the above observations could not have been made.

I have already described the form of tube illustrated in Fig. 1, and in Fig. 2 another still further improved design is shown. In this case the aluminum cap A, instead of having a straight bottom as before, is shaped spherically, the center of the sphere coinciding with that of the electrode *e*, which itself, as in Fig. 1, has its focus in the center of the window of cap A, as indicated by the dotted lines. The aluminum cap A has a tinfoil ring *r*, as that in Fig. 1, or else the metal of the cap is spun out on that place so as to afford a bearing of small surface between the metal and the glass. This is an important practical detail as, by making the bearing surface small, the pressure per unit of area is increased and a more perfect joint made. The ring *r* should be first spun out and then ground to fit the neck of the bulb. If a tinfoil ring is used instead, it may be cut out of one of the ordinary tinfoil caps obtainable in the market, care being taken that the ring is very smooth.

In Fig. 3 I have shown a modified design of tube which, as the two types before described, was comprised in the collection I exhibited. This, as will be observed, is a double-focus tube, with impact plates of iridium alloy and an aluminum cap A opposite the same. The tube is not shown because of any originality in design, but simply to illustrate a practical feature. It will be noted that the aluminum caps in the tubes described are fitted inside of the necks and not

... this precaution if pr
is taken in their preparat
inserting the cap the latter
down as low as it is deemed
without endangering the g
it is then gently pushed in
of the tube, taking care th
straight.

The two most important c
in the manufacture of suc
are, however, the thinning
the aluminum window and
ing in of the cap. The me
latter may be one thirty-s
even one-sixteenth of an in
and in such case the centr
may be thinned down by a
sink tool about one-fourth
in diameter as far as it i
without tearing the shee
further thinning down ma
done by hand with a scra
and, finally, the metal
gently beaten down so as
close the pores which migh
slow leak. Instead of pro
this way I have employed a
a hole in the center, whi
closed with a sheet of pure
a few thousandths of an i
riveted to the cap by m
washer of thick metal, but
were not quite as satisfacto

In sealing the cap I hav
the following procedure: T
fastened on the pump in
position and exhausted u
manent condition is reach
degree of exhaustion is a m
perfection of the joint. T
usually considerable, but th
serious a defect as might b
Heat is now gradually app
tube by means of a gas st
temperature up to about
point of sealing wax is reac
space between the cap and
is then filled with sealing w
quality; and, when the lat
to boil, the temperature is
allow its settling in the ca
heat is then again increase
process of heating and co
peated several times until
cavity, upon reduction of t
ature, is found to be filled
with the wax, all bubbles h
appeared. A little more w
put on the top and the
carried on for an hour or
ing to the capacity of the
application of moderate h
below the melting point of

A tube prepared in th
will maintain the vacuum
and will last indefinitely.
used for a few months, it m
ally lose the high vacuu
can be quickly worked u
ever, if after long use it
necessary to clean the tu
easily done by gently warm
taking off the cap. The

described, in which the primary is operated by the discharges of a condenser. With such an instrument any desired suddenness of the impulses may be secured, there being practically no limit in this respect, as the energy accumulated in the condenser is the most violently explosive agent we know, and any potential or electrical pressure is obtainable. Indeed, I found that in increasing the suddenness of the electro motive impulses through the tube—without, however, increasing, but rather diminishing the total energy conveyed to it—phosphorescence was observed and rays began to appear, first the feebler Lenard rays and later, by pushing the suddenness far enough, Roentgen rays of great intensity, which enabled me to obtain photographs showing the finest texture of the bones. Still, the same tube, when again operated with the ordinary coil of a low rate of change in the primary current, emitted practically no rays, even when, as before stated, much more energy, as judged from the heating, was passed through it. This experience, together with the fact that I have succeeded in producing by the use of immense electrical pressures, obtainable with certain apparatus designed for this express purpose, some impressions in free air, have led me to the conclusion that in lightning discharges Lenard and Roentgen rays must be generated at ordinary atmospheric pressure.

At this juncture I realize, by a perusal of the preceding lines, that my scientific interest has dominated the practical, and that the following remarks must be devoted to the primary object of this communication—that is, to giving some data for the construction to those engaged in the manufacture of the tubes and, perhaps, a few useful hints to practicing physicians who are dependent on such information. The foregoing was, nevertheless, not lost for this object, inasmuch as it has shown how much the result obtained depends on the proper construction of the instruments, for, with ordinary implements, most of the above observations could not have been made.

I have already described the form of tube illustrated in Fig. 1, and in Fig. 2 another still further improved design is shown. In this case the aluminum cap A, instead of having a straight bottom as before, is shaped spherically, the center of the sphere coinciding with that of the electrode *e*, which itself, as in Fig. 1, has its focus in the cen- ... window of cap A, as indi- outside, as is frequently done. Long experience has demonstrated that it is practically impossible to maintain a high vacuum in a tube with an outside cap. The only way I have been able to do this in a fair measure is by cooling the cap by a jet of air, for instance, and observing the following precautions: The air jet is first turned on slightly and upon this the tube is excited. The current through the latter, and also the air pressure, are then gradually increased and brought to the normal working condition. Upon completing the experiment the air pressure and current through the tube are both gradually reduced and both so manipulated that no great differences in temperature result between the glass and aluminum cap. If these precautions are not observed the vacuum will be immediately impaired in consequence of the uneven expansion of the glass and metal.

With tubes, as these presently described, it is quite unnecessary to observe this precaution if proper care is taken in their preparation. In inserting the cap the latter is cooled down as low as it is deemed advisable without endangering the glass, and it is then gently pushed in the neck of the tube, taking care that it sets straight.

The two most important operations in the manufacture of such a tube are, however, the thinning down of the aluminum window and the sealing in of the cap. The metal of the latter may be one thirty-second or even one-sixteenth of an inch thick, and in such case the central portion may be thinned down by a countersink tool about one-fourth of an inch in diameter as far as it is possible without tearing the sheet. The further thinning down may then be done by hand with a scraping tool; and, finally, the metal should be gently beaten down so as to surely close the pores which might permit a slow leak. Instead of proceeding in this way I have employed a cap with a hole in the center, which I have closed with a sheet of pure aluminum a few thousandths of an inch thick, riveted to the cap by means of a washer of thick metal, but the results were not quite as satisfactory.

In sealing the cap I have adopted the following procedure: The tube is fastened on the pump in the proper position and exhausted until a permanent condition is reached. The degree of exhaustion is a measure of perfection of the joint. The leak is usually considerable, but this is not so serious a defect as might be thought. Heat is now gradually ... may be done first with acid, then with highly diluted alkali, next with distilled water, and finally with pure rectified alcohol.

These tubes, when properly prepared, give impressions much sharper and reveal much more detail than those of ordinary make. It is important for the clearness of the impressions that the electrode should be properly shaped, and that the focus should be exactly in the center of the cap or slightly inside. In fitting in the cap, the distance from the electrode should be measured as exactly as possible. It should also be remarked that the thinner the window, the sharper are the impressions, but it is not advisable to make it too thin, as it is apt to melt in a point on turning on the current.

The above advantages are not the only ones which these tubes offer. They are also better adapted for purposes of examination by surgeons, particularly if used in the peculiar manner illustrated in diagrams Fig. 3 and Fig. 4, which are self-explanatory. It will be seen that in each of these the cap is connected to the ground. This decidedly diminishes the injurious action and enables also to take impressions with very short exposures of a few seconds only at close range, inasmuch as, during the operation of the bulb, one can easily touch the cap without any inconvenience, owing to the ground connection. The arrangement shown in Fig. 4 is particularly advantageous with a form of single terminal, which coil I have described on other occasions and which is diagramatically illustrated, P being the primary and S the secondary. In this instance the high-potential terminal is connected to the electrode, while the cap is grounded. The tube may be placed in the position indicated in the drawing, under the operating table and quite close, or even in contact with the body of the patient, if the impression requires only a few seconds as, for instance, in examining parts of the members. I have taken many impressions with such tubes and have observed no injurious action, but I would advise not to expose for longer than two or three minutes at very short distances. In this respect the experimenter should bear in mind what I have stated in previous communications. At all events it is certain that, in proceeding in the manner described, additional safety is obtained and the process of taking impressions much quickened. To cool the cap, a jet of air may be used, as before stated, or else a small quan-

... till, the same tube, when again operated with the ordinary coil of a low rate of change in the primary current, emitted practically no rays, even when, as before stated, much more energy, as judged from the heating, was passed through it. This experience, together with the fact that I have succeeded in producing by the use of immense electrical pressures, obtainable with certain apparatus designed for this express purpose, some impressions in free air, have led me to the conclusion that in lightning discharges Lenard and Roentgen rays must be generated at ordinary atmospheric pressure.

At this juncture I realize, by a perusal of the preceding lines, that my scientific interest has dominated the practical, and that the following remarks must be devoted to the primary object of this communication—that is, to giving some data for the construction to those engaged in the manufacture of the tubes and, perhaps, a few useful hints to practicing physicians who are dependent on such information. The foregoing was, nevertheless, not lost for this object, inasmuch as it has shown how much the result obtained depends on the proper construction of the instruments, for, with ordinary implements, most of the above observations could not have been made.

I have already described the form of tube illustrated in Fig. 1, and in Fig. 2 another still further improved design is shown. In this case the aluminum cap A, instead of having a straight bottom as before, is shaped spherically, the center of the sphere coinciding with that of the electrode *e*, which itself, as in Fig. 1, has its focus in the center of the window of cap A, as indicated by the dotted lines. The aluminum cap A has a tinfoil ring *r*, as that in Fig. 1, or else the metal of the cap is spun out on that place so as to afford a bearing of small surface between the metal and the glass. This is an important practical detail as, by making the bearing surface small, the pressure per unit of area is increased and a more perfect joint made. The ring *r* should be first spun out and then ground to fit the neck of the bulb. If a tinfoil ring is used instead, it may be cut out of one of the ordinary tinfoil caps obtainable in the market, care being taken that the ring is very smooth.

In Fig. 3 I have shown a modified design of tube which, as the two types before described, was comprised in the collection I exhibited. This, as will be observed, is a double-focus tube, with impact plates of iridium alloy and an aluminum cap A opposite the same. The tube is not shown because of any originality in design, but simply to illustrate a practical feature. It will be noted that the aluminum caps in the tubes described are fitted inside of the necks and not ... not observed the vacuum will be immediately impaired in consequence of the uneven expansion of the glass and metal.

With tubes, as these presently described, it is quite unnecessary to observe this precaution if proper care is taken in their preparation. In inserting the cap the latter is cooled down as low as it is deemed advisable without endangering the glass, and it is then gently pushed in the neck of the tube, taking care that it sets straight.

The two most important operations in the manufacture of such a tube are, however, the thinning down of the aluminum window and the sealing in of the cap. The metal of the latter may be one thirty-second or even one-sixteenth of an inch thick, and in such case the central portion may be thinned down by a countersink tool about one-fourth of an inch in diameter as far as it is possible without tearing the sheet. The further thinning down may then be done by hand with a scraping tool; and, finally, the metal should be gently beaten down so as to surely close the pores which might permit a slow leak. Instead of proceeding in this way I have employed a cap with a hole in the center, which I have closed with a sheet of pure aluminum a few thousandths of an inch thick, riveted to the cap by means of a washer of thick metal, but the results were not quite as satisfactory.

In sealing the cap I have adopted the following procedure: The tube is fastened on the pump in the proper position and exhausted until a permanent condition is reached. The degree of exhaustion is a measure of perfection of the joint. The leak is usually considerable, but this is not so serious a defect as might be thought. Heat is now gradually applied to the tube by means of a gas stove until a temperature up to about the boiling point of sealing wax is reached. The space between the cap and the glass is then filled with sealing wax of good quality; and, when the latter begins to boil, the temperature is reduced to allow its settling in the cavity. The heat is then again increased, and this process of heating and cooling is repeated several times until the entire cavity, upon reduction of the temperature, is found to be filled uniformly with the wax, all bubbles having disappeared. A little more wax is then put on the top and the exhaustion carried on for an hour or so, according to the capacity of the pump, by application of moderate heat much below the melting point of the wax.

A tube prepared in this manner will maintain the vacuum very well, and will last indefinitely. If not used for a few months, it may gradually lose the high vacuum, but it can be quickly worked up. However, if after long use it becomes necessary to clean the tube, this is easily done by gently warming it and taking off the cap. The cleaning ...

The above advantages are not the only ones which these tubes offer. They are also better adapted for purposes of examination by surgeons, particularly if used in the peculiar manner illustrated in diagrams Fig. 3 and Fig. 4, which are self-explanatory. It will be seen that in each of these the cap is connected to the ground. This decidedly diminishes the injurious action and enables also to take impressions with very short exposures of a few seconds only at close range, inasmuch as, during the operation of the bulb, one can easily touch the cap without any inconvenience, owing to the ground connection. The arrangement shown in Fig. 4 is particularly advantageous with a form of single terminal, which coil I have described on other occasions and which is diagramatically illustrated, P being the primary and S the secondary. In this instance the high-potential terminal is connected to the electrode, while the cap is grounded. The tube may be placed in the position indicated in the drawing, under the operating table and quite close, or even in contact with the body of the patient, if the impression requires only a few seconds as, for instance, in examining parts of the members. I have taken many impressions with such tubes and have observed no injurious action, but I would advise not to expose for longer than two or three minutes at very short distances. In this respect the experimenter should bear in mind what I have stated in previous communications. At all events it is certain that, in proceeding in the manner described, additional safety is obtained and the process of taking impressions much quickened. To cool the cap, a jet of air may be used, as before stated, or else a small quantity of water may be poured in the cap each time when an impression is taken. The water only slightly impairs the action of the tube, while it maintains the window at a safe temperature. I may add that the tubes are improved by providing back of the electrode a metallic coating C, shown in Fig. 3 and Fig. 4.

NIKOLA TESLA.

New York, August 9.

Electric Light Plant Wanted.

Mr. T. J. Lillard, treasurer of the Elkin Manufacturing Company, of Elkin, Surry County, N. C., manufacturers of cotton yarns, twines, etc., writes to the ELECTRICAL REVIEW, under date of August 7, as follows:

"We want prices and estimates on a 400-light incandescent dynamo, switchboard, wire and everything used, to light the town of Elkin with, say 100 16-candle-power street lights, and for 30 stores and residences with eight lights each.

Electrical.... Patents.

[Specially reported for this journal by E. S. Duvall, solicitor of patents, Loan and Trust Building, Washington, D. C. Copies of any patent may be secured for 10 cents each.]

ISSUED JULY 27, 1897.

587,081 Telephone exchange apparatus; F. R. McBerty, Downer's Grove, Ill.—A telephone line grounded at two points subject to differences of potential and provided with a generator of alternating current at one sub-station and an annunciator at the other station, a group of polarization cells in one of the ground branches.

587,114 Electric condenser; C. S. Bradley, Avon, N. Y.—An electric condenser having its pile of plates inclosed in a fluid and air-tight metallic casing hermetically sealed at all joints, whereby the access of moisture in the outside air is prevented and the capacity is kept unaltered.

587,119 Telephony; J. W. Gibboney, Lynn, Mass.

587,120 Telephony; J. W. Gibboney, Lynn, Mass.—A bell-operating magnet having upon its core a primary coil in the main line circuit, and a transmitter and receiver in a local circuit of coarser wire forming a secondary to said primary coil.

587,143 Electric programme clock; E. Bobsien, Mount Vernon, N. Y.

587,163 Multipolar dynamo electric machine; S. W. Rushmore, Brooklyn, N. Y.—An armature, several magnets arranged about the armature and sets of brushes for separately collecting the currents generated in the parts of the armature under the different magnets, independently of other sections, and connections from each set of brushes through the field coil of its magnet only.

587,164 Dynamo-electric machine; S. W. Rushmore, Brooklyn, N. Y.

587,182 Electric furnace; G. de Chalmot, Leaksville, N. C.—Consists of the carbon pencil and a crucible or hollow hearth, wheels on which said crucible is mounted, a track on which said wheels roll, and a mechanism for reciprocating said crucible by rolling it back and forth on said track.

587,204 Switchboard annunciator; N. H. Holland, Montreal, Canada.

587,217 Fuse-holder and electric cut-outs; H. A. Lewis, Norristown, Pa.

587,226 Telephone trunk-circuit; J. J. O'Connell, Chicago, Ill.

ISSUED AUGUST 3, 1897.

587,296 Electric bale-tie machine; W. O. Bates, Joliet, Ill.

587,311 Regulating admission of currents to motors; F. E. Herdman, Winnetka, Ill.

587,336 Telegraphy; F. M. Short, Cleveland, Ohio.

587,340 Operating alternating motors; C. P. Steinmetz, Lynn, Mass.—Consists in feeding alternating currents to one member of one such motor from a source of power supply, converting the energy so supplied to the motor partly into mechanical energy expended in driving a driven mechanism, and partly into electrical energy in the form of alternating currents induced in the secondary element of the motor, and supplying a second alternating motor with the said secondary currents.

587,343 Electric furnace; G. S. Strong, New York, N. Y.—The improvement in the art of electric smelting, which consists in forming electrodes of a mass of material including a material which will bind the mass together under pressure and simultaneously agglomerating, forming and feeding said mixture forward to a furnace by pressure.

587,379 Dynamo-electric machine; E. P. Warner, Chicago, Ill.—Consists of cores carrying the field coils, the pole-pieces connected therewith by two or more constructed necks or paths, said necks or paths being proportioned to carry the necessary lines of force of the main field when at practical saturation point to thereby prevent the passage of lines of force due to the armature coils.

587,405 Signal for telephone switchboards; C. E. Scribner, Chicago, Ill.—Two terminal plugs of a pair and the plug circuit thereof, means for connecting a generator of signaling current with one of the plugs, a bridge of the plug circuit, a source of current and a signal in the bridge, and another signal included in a conductor of the plug circuit between the said bridge and that plug with which the generator of signaling current may be connected.

587,406 Apparatus for telephone switch boards; C. E. Scribner, Chicago, Ill.

587,421 Electric arc lamp; S. Bergmann, New York, N. Y.

587,433 Electric signaling apparatus; M. Du Perow, Washington, D. C.

587,435 Automatic telephone system; M. Freudenberg, Paris, France.

587,436 Electro-therapeutic apparatus; F. Geiger, Philadelphia, Pa.—A main circuit, a patient or operator circuit; a fixed resistance in series with the operator circuit, and a variable resistance in the main circuit, and in shunt with the patient or operator circuit.

587,437 Apparatus for manufacturing chlorate of potash by electrolysis; Fer. Hurter, Liverpool, England—A cathode consisting of a metallic vessel having a porous protective lining.

587,441 Regulating apparatus for electrically driven machinery; W. H. Knight, Newton, Mass.

587,442 Method of regulating electrically driven mechanism; W. H. Knight, Newton, Mass.

587,458 Electric switch; H. W. Smith, Pittsfield, Mass.—Comprises a block, a tapering undercut recess therein, a contact plate bent to correspond substantially with said recess, and a pin within said recess to secure said plate in place.

587,465 Electric arc lamp; E. F. Taylor, West Chester, Pa.

587,467 Telephone central station signaling circuit; G. K. Thompson, Malden, Mass.

587,502 Central office switchboard system; W. S. Harrison, Chicago, Ill.

587,507 Electric signal device for elevators; O. Raacke, St. Louis, Mo.

587,531 Electric motor or dynamo-electric machine; R. Lundell, Brooklyn—An electric motor having a rotary armature and a field magnet composed of duplicate or interchangeable parts with overlapping field magnet poles surrounded by an energizing coil inclined at an angle to the axis of the armature and permitting of removal thereof without disturbing the field magnet.

587,534 Electrical alarm for cars; A. Nathan, New York, N. Y.

587,553 Electric signal box; A. T. Whittlesey, Cleveland, Ohio.

587,568 Electrolytic heating apparatus; G. D. Burton, Boston, Mass.—Consists of a tank provided with an electrode adapted to contact with the contents of the tank, with a second electrode adjacent to said tank, an adjustable rest adjacent to said second electrode.

587,576 Dynamo electric machine; C. M. Green, Cleveland, Ohio—Consists of a series of commutator rings, of armature coils connected with commutator segments at the same side of the armature at which the coils are located, and several sets of commutator brushes to engage said commutator rings.

587,591 Device for closing windows; H. I. Luyre, New York, N. Y.

587,594 Electric contact; A. J. Moxham, Lorain, Ohio—A metallic cover plate, having a perforation and upward projections on each side thereof, in combination with the contact secured in said perforation, but insulated from said projections.

587,614 Electric wire holder; C. J. Stram, Waterman, Ill.

587,642 Electric contact box; W. M. Brown, Johnstown, Pa.—Comprises a fixed contact and a contact-carrying armature, a spring encircling and secured to said armature and to a fixed portion of the mechanism.

587,649 Electrocution chair; E. F. Davis, West Caton, N. Y.—A chair having means for passing an electric current through a person seated therein, a foot rest, a seat registering the weight of an individual and an adjustable back.

587,663 Telautograph; G. S. Tiffany, Highland Park, Ill.

587,669 Burglar alarm system; W. T. Arnold, Chicago, Ill.

587,674 Electric railway; R. M. Hunter, Philadelphia, Pa.

Tesla's System of Energy Transmission to a Distance Without Wires.

In view of the many reports which are appearing in the sensational dailies about Tesla's work, it appears only justice to this earnest and modest worker that we should publish the following sensible statement reported in such a competent and carefully edited journal as the *Sun*, of this city. The statement is reported as follows in its evening issue of August 4:

Nikola Tesla this morning denied the report that he had announced the completion of his discovery of a method of telegraphy without wires. Occasional reports of the progress of the work had been published from time to time, he said. His experiments had been repeatedly shown in strict confidence to some of his personal friends, but the publication of them in any detail must have been a violation of confidence. As a matter of fact, no experiments were made at the laboratory yesterday. The inventor, however, was willing to give some account of his work up to the present time.

"In a lecture delivered about four years ago," he said, "before the National Electric Light Association, in St. Louis—that was in March, 1893—I explained a certain scheme for producing electrical disturbances with the object of transmitting intelligible messages, and even power, from place to place without the use of any wires.

"The principle is this: An electrical oscillator is connected by one of its terminals to earth, and another is led to an insulated object of considerable bulk. This object should preferably be at a great height, where the air is less dense and transmits more easily the disturbance.

"Such an apparatus is then exactly what in mechanics would be a suction pump. Periodically it draws electricity out and forces it again into the earth, thereby altering rhythmically the electrostatic potential in the earth as well as in the air.

"This scheme I had, as a matter of fact, conceived many years before. But I had previously lacked the courage to present it to the scientific world. At the time of the St. Louis lecture I had already seen such results that I gathered courage enough to announce the project seriously.

"Shortly afterward, on my return to this city, I actually demonstrated by means of an improved apparatus that I was indeed able to create a disturbance in the manner described in the lecture.

"In my pleasure and excitement at this success, I could not refrain from showing the first experiments to a few intimate friends. When, later, my laboratory burned down, and the first instrument with which I had succeeded in my demonstration, and which I valued above any other, was destroyed, it was no small consolation to me that a few men whom I hold in high esteem had seen the first evidence of my success. They were my friends. Of course, all the experiments that I have made to this day have been shown only in confidence and with the express understanding that no popular publication should be made of them until I had acquainted the scientific world with my results.

"It appeared several years ago that the result I aimed at would be very difficult, if not impossible, to attain. The method, nevertheless, as I have outlined it, is simple, involving merely the use of a properly constructed oscillator connected with the ground, and with an elevated object; also a sensitive and properly adjusted receiver at a distance, similarly connected with the ground, and with an object at a considerable height. For the purposes of this receiver, I consider a balloon most suitable.

"These disturbances with which I am experimenting are produced by methods and devices which I have been perfecting more recently, and from present results I do not consider it at all impracticable to obtain, if such were desired, electric sparks a mile in length. They could be readily secured by apparatus designed on these novel lines. I now obtain sparks as long as eight feet, and can produce local disturbances. What I affirm is that the disturbances in this city may be made perceptible in London or throughout the world.

"The voltage is very high—beyond computation. For a wild guess I should place the voltage at 50,000,000. I have stood in the course of the sparks, but I consider them dangerous.

"Scientific results are what I have been chiefly interested in. But there are many possibilities of turning the methods to practical use. For instance, if I wished to make a fortune I should only have to take out patents on methods for exploding torpedoes or powder magazines at a distance by means of electrical disturbances produced in this manner. But to dispel popular and erroneous opinions on this point, it is appropriate to say that, whereas, it is perfectly possible to ignite an explosive by a suitably arranged apparatus at a distance, yet this fact will not revolutionize warfare. The enemy could avail himself of similar methods with like results."

The Mayor and Gas Committee will receive bids to light the City of Waco, on an all-night and also on a moonlight schedule, with 125 to 200 arc lights, 2,000 c.-p., for a term of two to five years. We will also receive bids to install an electric light plant, specifications for which will be furnished by City Engineer on demand. All bids must be accompanied by a $1,000 certified check. We reserve the right to reject any or all bids. The bids will be opened by the Mayor and Gas Committee at 3 P. M., October 7th, 1897.

C. C. McCulloch,
Mayor, Waco, Texas.

Attest:
R. W. Joblonowski,
City Secretary.

The Mountain Chautauqua.

This famous Chautauqua, at Mountain Lake Park, Md., opens its session August 4 and closes August 24. It is the most superb and sensible Summer resort in America. Its height, 2,800 feet above sea level, means a delightful climate and unsurpassed mountain views. Five well appointed hotels and 250 cottages open their doors to tourists at from $5 to $12 per week. Twenty departments of important school work are in the hands of specialists. The best lecturers, singers and entertainers in the country appear three times daily. The programme is unequaled. Here is a chance to mix a little intellectual uplift with your vacation.

Mountain Lake Park is located on the main line of the B. & O. Railroad, and as all the fast trains stop at the Park during the Summer, patrons have the advantage of their superb train service between the East and the West.

Round trip tickets will be sold from all stations east of the Ohio River for all trains August 2 to 23, valid for return trip until August 31, at ONE SINGLE FARE for the ROUND TRIP.

For illustrated pamphlet and all other information, address agent B. & O. Railroad, Mountain Lake Park, Md.

587,406 Apparatus for telephone switchboards; C. E. Scribner, Chicago, Ill.

587,421 Electric arc lamp; S. Bergmann, New York, N. Y.

587,433 Electric signaling apparatus; M. Du Perow, Washington, D. C.

587,435 Automatic telephone system; M. Freudenberg, Paris, France.

587,436 Electro-therapeutic apparatus; F. Geiger, Philadelphia, Pa.—A main circuit, a patient or operator circuit; a fixed resistance in series with the operator circuit, and a variable resistance in the main circuit, and in shunt with the patient or operator circuit.

587,437 Apparatus for manufacturing chlorate of potash by electrolysis; Fer. Hurter, Liverpool, England—A cathode consisting of a metallic vessel having a porous protective lining.

587,441 Regulating apparatus for electrically driven machinery; W. H. Knight, Newton, Mass.

587,442 Method of regulating electrically driven mechanism; W. H. Knight, Newton, Mass.

587,458 Electric switch; H. W. Smith, Pittsfield, Mass.—Comprises a block, a tapering undercut recess therein, a contact plate bent to correspond substantially with said recess, and a pin within said recess to secure said plate in place.

587,465 Electric arc lamp; E. F. Taylor, West Chester, Pa.

587,467 Telephone central station signaling circuit; G. K. Thompson, Malden, Mass.

587,502 Central office switchboard system; W. S. Harrison, Chicago, Ill.

587,507 Electric signal device for elevators; O. Raacke, St. Louis, Mo.

587,531 Electric motor or dynamo-electric machine; R. Lundell, Brooklyn—An electric motor having a rotary armature and a field magnet composed of duplicate or interchangeable parts with overlapping field magnet poles surrounded by an energizing coil inclined at an angle to the axis of the armature and permitting of removal thereof without disturbing the field magnet.

587,534 Electrical alarm for cars; A. Nathan, New York, N. Y.

587,535 Electric signal box; A. T. Whittlesey, Cleveland, Ohio.

587,568 Electrolytic heating apparatus; G. D. Burton, Boston, Mass.—Consists of a tank provided with an electrode adapted to contact with the contents of the tank, with a second electrode adjacent to said tank, an adjustable rest adjacent to said second electrode.

587,576 Dynamo electric machine; C. M. Green, Cleveland, Ohio—Consists of a series of commutator rings, of armature coils connected with commutator segments at the same side of the armature at which the coils are located, and several sets of commutator brushes to engage said commutator rings.

587,591 Device for closing windows; H. I. Luyre, New York, N. Y.

587,594 Electric contact; A. J. Moxham, Lorain, Ohio—A metallic cover plate, having a perforation and upward projections on each side thereof, in combination with the contact secured in said perforation, but insulated from said projections.

587,614 Electric wire holder; C. J. Stram, Waterman, Ill.

587,642 Electric contact box; W. M. Brown, Johnstown, Pa.—Comprises a fixed contact and a contact-carrying armature, a spring encircling and secured to said armature and to a fixed portion of the mechanism.

587,649 Electrocution chair; E. F. Davis, West Caton, N. Y.—A chair having means for passing an electric current through a person seated therein, a foot rest, a seat registering the weight of an individual . . .

Tesla's System of Energy Transmission to a Distance Without Wires.

In view of the many reports which are appearing in the sensational dailies about Tesla's work, it appears only justice to this earnest and modest worker that we should publish the following sensible statement reported in such a competent and carefully edited journal as the *Sun*, of this city. The statement is reported as follows in its evening issue of August 4:

Nikola Tesla this morning denied the report that he had announced the completion of his discovery of a method of telegraphy without wires. Occasional reports of the progress of the work had been published from time to time, he said. His experiments had been repeatedly shown in strict confidence to some of his personal friends, but the publication of them in any detail must have been a violation of confidence. As a matter of fact, no experiments were made at the laboratory yesterday. The inventor, however, was willing to give some account of his work up to the present time.

"In a lecture delivered about four years ago," he said, "before the National Electric Light Association, in St. Louis—that was in March, 1893—I explained a certain scheme for producing electrical disturbances with the object of transmitting intelligible messages, and even power, from place to place without the use of any wires.

"The principle is this: An electrical oscillator is connected by one of its terminals to earth, and another is led to an insulated object of considerable bulk. This object should preferably be at a great height, where the air is less dense and transmits more easily the disturbance.

"Such an apparatus is then exactly what in mechanics would be a suction pump. Periodically it draws electricity out and forces it again into the earth, thereby altering rhythmically the electrostatic potential in the earth as well as in the air.

"This scheme I had, as a matter of fact, conceived many years before. But I had previously lacked the courage to present it to the scientific world. At the time of the St. Louis lecture I had already seen such results that I gathered courage enough to announce the project seriously.

"Shortly afterward, on my return to this city, I actually demonstrated by means of an improved apparatus that I was indeed able to create a disturbance in the manner described in the lecture.

"In my pleasure and excitement at this success, I could not refrain from showing the first experiments to a few intimate friends. When, later, my laboratory burned down, and the first instrument with which I had succeeded in my demonstration, and which I valued above any other, was destroyed, it was no small consolation to me that a few men whom I hold in high esteem had seen the first evidence of my success. They were my friends. Of course, all the experiments that I have made to this day have been shown only in confidence and with the express understanding that no popular publication should be made of them until I had acquainted the scientific world with my results.

"It appeared several years ago that the result I aimed at would be very difficult, if not impossible, to attain. The method, nevertheless, as I have outlined it, is simple, involving merely the use of a properly constructed oscillator connected with the ground, and with an elevated object; also a sensitive and properly adjusted receiver at a distance, similarly connected with the ground, and with an object at a considerable height. For the purposes of this receiver, I consider a balloon most suitable.

"These disturbances with which I am experimenting are produced by methods and devices which I have been perfecting more recently, and from present results I do not consider it at all impracticable to obtain, if such were desired, electric sparks a mile in length. They could be readily secured by apparatus designed on these novel lines. I now obtain sparks as long as eight feet, and can produce local disturbances. What I affirm is that the disturbances in this city may be made perceptible in London or throughout the world.

"The voltage is very high—beyond computation. For a wild guess I should place the voltage at 50,000,000. I have stood in the course of the sparks, but I consider them dangerous.

"Scientific results are what I have been chiefly interested in. But there are many possibilities of turning the methods to practical use. For instance, if I wished to make a fortune I should only have to take out patents on methods for exploding torpedoes or powder magazines at a distance by means of electrical disturbances produced in this manner. But to dispel popular and erroneous opinions on this point, it is appropriate to say that, whereas, it is perfectly possible to ignite an explosive by a suitably arranged apparatus at a distance, yet this fact will not revolutionize warfare. The enemy could avail himself of similar methods with like results."

SCIENTIFIC AMERICAN

[Entered at the Post Office of New York, N. Y., as Second Class Matter. Copyright, 1901, by Munn & Co.]

A WEEKLY JOURNAL OF PRACTICAL INFORMATION, ART, SCIENCE, MECHANICS, CHEMISTRY, AND MANUFACTURES.

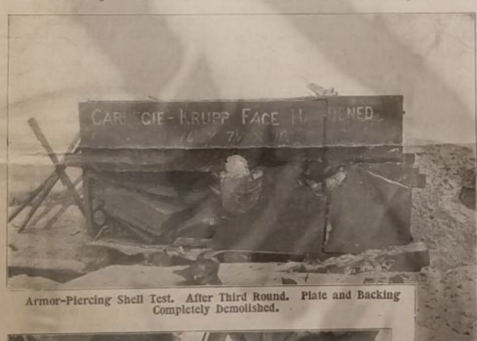
Vol. LXXXV.—No. 22.
ESTABLISHED 1845.

NEW YORK, NOVEMBER 30, 1901.

$3.00 A YEAR.
8 CENTS A COPY.

Armor-Piercing Shot Test. First Round. Plate Penetrated and Backing Wrecked.

Gathmann Shell Test. Target Before Firing, Backing Representing Side of "Iowa."



Armor-Piercing Shell Test. After Third Round. Plate and Backing Completely Demolished.

Gathmann Shell Test. Third Round. Target and Backing Driven 8 Feet to Rear and 8 Feet to Left of Original Position. Note Relative Position of Track and Target.

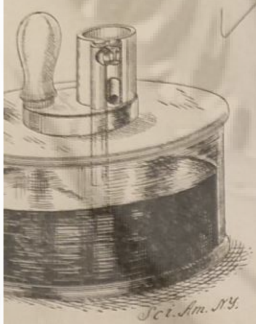
Armor-Piercing Shell Test. Rear of Target, Showing Extraordinary Destruction of Steel Frame Backing.

Armor-Piercing Shell Test. 1½-Ton Fragment of Plate Blown Through Backing and 200 Feet to Rear. Head of Shell Lying on Target.

Gathmann Shell Test. View from Rear of Gun, Showing Torpedo Shell; Screens and Target in Distance.

TESTS OF HIGH-EXPLOSIVE SHELL AT SANDY HOOK.—[See page 344.]

d deposit ...
use, but frequently clogs
vents the replenishing of
inkwell pictured is free
has its long leg extended
ort leg in communication
A port pierces the wall
and communicates with
veen its ends. A valve



IPHON INKWELL.

siphon and will escape
ort. In order to retain
after releasing the bulb,
d piercing the short leg
of the dip-well at a dis-
n of a proper amount of

entor has conceived the
s by electricity, and has
trocuting-trap. The base

TRICAL MOUSE-TRAP.

he superposed platform in
t leaps upon the platform
circuit is closed and the
gh its body.
ball-bearing wheel is a
ck P. Vaughan, of Perry,

... electric saw and jimmy for ... His companion carried an electric lamp instead of the old-fashioned oil-lantern. The two burglars were well-dressed and had good manners. They are said to be skillful mechanics. The police say that the electric bludgeon is one of the most dangerous weapons ever seen."

Tesla's Recent Patents.

Nikola Tesla has received several patents for a "Method of Intensifying and Utilizing Effects Transmitted Through Natural Media." In one of his systems Tesla varies the potential point or region of the earth by imparting to it intermittent or alternating electrifications through one of the terminals of a suitable source of electrical disturbances which, to heighten the effect, has its other terminal connected with an insulated body, preferably of large surface and at an elevation. Electrifications communicated to the earth spread in all directions, reaching a circuit which generally has its terminals arranged and connected similarly to those of the transmitting source, and which operates upon a highly sensitive receiver. Another of Tesla's methods is based upon the fact that the atmospheric air, which behaves as an excellent insulator to currents generated by ordinary apparatus, becomes a conductor under the influence of currents or impulses of enormously high electromotive force. By such means air strata, which are easily accessible, are rendered available for the production of many desired effects at distances. Although either method may be employed, it is obviously desirable that the disturbance should be as powerful as possible and should be transmitted with a minimum loss. The loss reduces greatly both the intensity and the number of the co-operative impulses, and since the initial intensity of each of these is necessarily limited, only an insignificant amount of energy is thus available for a single operation of the receiver. Furthermore, the energy obtained through the co-operation of the impulses is in the form of an extremely rapid vibration and unsuitable for the operation of ordinary receivers. To overcome these limitations of the two methods mentioned, Tesla reproduces arbitrarily varied or intermittent disturbances or effects; transmits these disturbances through the air to a distant receiving station; utilizes the energy derived from such disturbances at the receiving station to charge a condenser; and uses the accumulated potential so obtained to operate a receiving device.

The apparatus which is employed at the receiving station consists in the combination of a storage device included in a circuit; connection points at a distance from the source of the disturbances and between which a difference of potential is created by such disturbances; a receiving circuit connected with the storage device; a receiver included in the receiving circuit, and a mechanism for closing the receiving circuit at any desired moment, thereby causing the receiver to be operated by the energy with which the storage device has been charged.

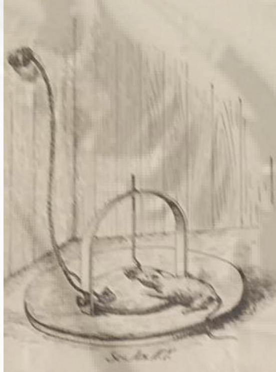
In another method the energy stored is not, as in the preceding ... energy of

erful ...
tion or contr...
rendered useful in many othe...
energy is directed upon an el...
nected with one of the armat...
positively electrified by the inv...
electricity is carried off from ...
connecting it with the ground. ...
ergy is discharged through a ...

Recent Improvements in ...

Several patents have recent...
United States to Walther Ne...
and Marshall W. Hanks, for p...
signed to overcome various d...
noticeable in the Nernst la...
Mr. Potter intends to use se...
effect the heating of a single ...
glowers. A single spiral suffic...
with sufficient uniformity, but ...
current capacity are to be st...
be very evenly distributed to ...
glower. Instead of increasing ...
of wire of a small heater, wh...
Potter finds it cheaper to mul...
Several heaters equal in su...
heater, he finds, will heat u...
have but a fraction of the ...
Several heaters can be so dis...
that their combined effects ...
than a single spiral practical...
The quality possessed by t...
an increased conductivity un...
has been counterbalanced by ...
last-conductors placed in se...
But in the practical manufac...
last and of glowers having un...
conditions of practical use, it ...
an additional adjustment of ...
order to secure perfect worki...
sirable to employ a ballast ...
chamber, or so to construct ...
the ballast that it is not ...
Nernst has devised a divid...
which is standardized as per...
the remainder is adjusted a...
conditions of each glower. B...
divided ballast it is possible ...
imperfection in the standar...
glower, or both.
Mr. Nernst has likewise in...
for glowers. These composi...
of the oxide of zirconium n...
yttrium or cerium groups.
An effective and easily pra...
ing Nernst lamp glowers ...
adapted to circuits of a give...
of the patent granted to Mr. ...

n inventor has conceived the
nd rats by electricity, and has
n electrocuting trap. The base



ELECTRICAL MOUSE-TRAP.

nd the superposed platform in
e rat leaps upon the platform
the circuit is closed and the
hrough its body.

.—A ball-bearing wheel is a
ederick P. Vaughan, of Perry,

A BALL-BEARING WHEEL.

nventor states that the wheel
a minimum and is capable of
. Water is effectually excluded
e rim by reason of the peculiar
terlocked inner and outer rings.

Burglars' Tools.

t turn to European papers to
nterprising, inventive burglars
e way of devising more efficient
afes." It seems that some time
ught in New York upon whose
ic lamp of the cylindrical type
York sensational journals natur-
use of the electric light instead
lark lantern. The London Daily
with avidity, and enlarged upon
med the following shape: "The
ay arrested two thieves who had

sired effect... method may be employed, it is obviously desirable that the disturbance should be as powerful as possible and should be transmitted with a minimum loss. The loss reduces greatly both the intensity and the number of the co-operative impulses, and since the initial intensity of each of these is necessarily limited, only an insignificant amount of energy is thus available for a single operation of the receiver. Furthermore, the energy obtained through the co-operation of the impulses is in the form of an extremely rapid vibration and unsuitable for the operation of ordinary receivers. To overcome these limitations of the two methods mentioned, Tesla reproduces arbitrarily varied or intermittent disturbances or effects; transmits these disturbances through the air to a distant receiving station; utilizes the energy derived from such disturbances at the receiving station to charge a condenser; and uses the accumulated potential so obtained to operate a receiving device.

The apparatus which is employed at the receiving station consists in the combination of a storage device included in a circuit; connection points at a distance from the source of the disturbances and between which a difference of potential is created by such disturbances; a receiving circuit connected with the storage device; a receiver included in the receiving circuit, and a mechanism for closing the receiving circuit at any desired moment, thereby causing the receiver to be operated by the energy with which the storage device has been charged.

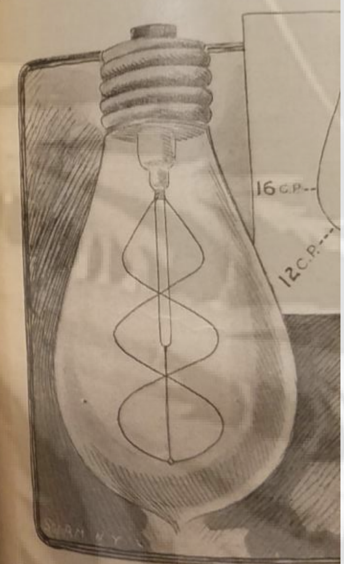
In another method the energy stored is not, as in the preceding instance, obtained from the energy of the disturbance effect transmitted from a distance, but from an independent source. The method in general consists in charging a storage device with energy from an independent source, controlling the charge of the device by the action of the effects or disturbances transmitted through the natural media, and coincidently using the stored energy for operating a receiver. A condenser is used as the storage means.

The invisible radiations of the spectrum and of vacuum tubes are generally considered to be vibrations of extremely small wave length. These radiations possess the property of charging and discharging conductors of electricity, the discharge being particularly noticeable when the conductor upon which the rays impinge is negatively electrified. It is usually held that these radiations ionize or render conducting the atmosphere through which they are propagated. Tesla's own experiments lead him, however, to conclusions more in accord with the theory he has already advanced, in which he holds that sources of such radiant energy throw off with great velocity minute particles of matter which are strongly electrified, and therefore capable of charging an electrical conductor, or, even if not so, of discharging an electrified conductor either by carrying off bodily its charge or otherwise. Tesla has taken out a patent based upon a discovery which he has made, that when rays or radiations of this kind are permitted to fall upon an insulated conducting body connected with one of the terminals of a condenser, while the other terminal is made by independent means to receive or carry away electricity, a current flows into the condenser so long as the insulated body is exposed to the rays. Under certain conditions an indefinite ac-

than the qu
The increased con
has been counterbalanced by the empl
last conductors placed in series with
but in the practical manufacture of s
bat and of glowers having uniform qua
conditions of practical use, it is someti
an additional adjustment of the balla
order to secure perfect working. It i
sirable to employ a ballast inclosed
chamber, or so to construct the prin
the ballast that it is not readily
Nernst has devised a divided balla
which is standardized as perfectly a
the remainder is adjusted according
conditions of each glower. By the em
divided ballast it is possible to com
imperfection in the standardized ba
glower, or both.

Mr. Nernst has likewise invented t
for glowers. These compositions c
of the oxide of zirconium mixed w
yttrium or cerium groups.

An effective and easily practised
ing Nernst lamp glowers wherel
adapted to circuits of a given volta
of the patent granted to Mr. Hanks.



THE IMPROVED FORM OF INCAND
MENT COMPARED WITH ONE
TYPE.

of glowers to any given voltag
length, cross section and compos
erally the practice to make the
circuits of any given voltage as
the same composition, the sam
same length. Despite the ut
in manufacture, more or less va
dition desired is likely to ensue
have been completed it is obvi
change the composition or to dec
ster or the length. Mr. Hank
to provide glowers which act
voltages than those for which

cumulation of electrical energy takes place. This energy after a suitable time interval, during which the rays are allowed to act, may manifest itself in a powerful discharge, which can be utilized for the operation or control of mechanical or electrical devices or rendered useful in many other ways. The radiant energy is directed upon an elevated conductor, connected with one of the armatures of the condenser, positively electrified by the invisible radiations. The electricity is carried off from the other armature by connecting it with the ground. The accumulated energy is discharged through a suitable receiver.

Recent Improvements in the Nernst Lamp.

Several patents have recently been issued in the United States to Walther Nernst, Henry N. Potter, and Marshall W. Hanks, for processes and devices designed to overcome various defects which have been noticeable in the Nernst lamp.

Mr. Potter intends to use several spirals of wire to effect the heating of a single glower, or a number of glowers. A single spiral suffices to heat small glowers with sufficient uniformity, but when glowers of large-current capacity are to be started up, the heat must be very evenly distributed to prevent cracking of the glower. Instead of increasing the diameter and length of wire of a small heater, which is rather costly, Mr. Potter finds it cheaper to multiply heaters in parallel. Several heaters equal in surface to a single large heater, he finds, will heat up more quickly, as they have but a fraction of the mass of the large one. Several heaters can be so distributed about a glower that their combined effects heat much more evenly than a single spiral practically can.

The quality possessed by the glowers of acquiring an increased conductivity under the influence of heat has been counterbalanced by the employment of ballast-conductors placed in series with the glowers. But in the practical manufacture of standardized ballast and of glowers having uniform qualities under the conditions of practical use, it is sometimes found that in addition ...

intended, with coatings of materia which is the same as that of th Assuming that the glowers to be adapted for higher voltages than are desired, Mr. Hanks subjects t dition to a cloud of powdered m same as that of the glower body is treated while hot and is rotat the powder will be deposited in a treatment is continued until a across the circuit from which ing the glower is derived, indic increase in cross-section has bee

THREE NEW ELECTRIC

The matter of rating the effi lamp of the incandescent type i the reason that the glow is found

... Recent Patents.

received several patents for a
ing and Utilizing Effects Trans-
ral Media." In one of his sys-
he potential point or region of
ng to it intermittent or alter-
through one of the terminals
f electrical disturbances which
has its other terminal connected
ly, preferably of large surface
Electrifications communicated to
l directions, reaching a circuit
s terminals arranged and con-
ose of the transmitting source,
on a highly sensitive receiver.
ods is based upon the fact that
ich behaves as an excellent in-
erated by ordinary apparatus,
ler the influence of currents or
high electromotive force. By
which are easily accessible, are
the production of many de-
es. Although either method
obviously desirable that the
as powerful as possible and
with a minimum loss. The
the intensity and the number
ses, and since the initial in-
is necessarily limited, only
of energy is thus available
the receiver. Furthermore,
ugh the co-operation of the
of an extremely rapid vibra-
he operation of ordinary re-
ese limitations of the two
sia reproduces arbitrarily
turbances or effects; trans-
rough the air to a distant
the energy derived from
receiving station to charge
e accumulated potential so
ving device.
employed at the receiving
nbination of a storage de-
connection points at a dis-
the disturbances and be-
of potential is created by
ing circuit connected with
er included in the receiving
for closing the receiving
moment, thereby causing
by the energy with which
charged.
nergy stored is not, as in
ained from the energy of
smitted from a distance,
urce. The method in gen-
storage device with en-
source, controlling the
action of the effects or
rough the natural media,
stored energy for operat-
r is used as the storage
and of

... connecting ... is discharged ... suitable receiver ... ated energy is discharged ...

Recent Improvements in the Nernst Lamp.

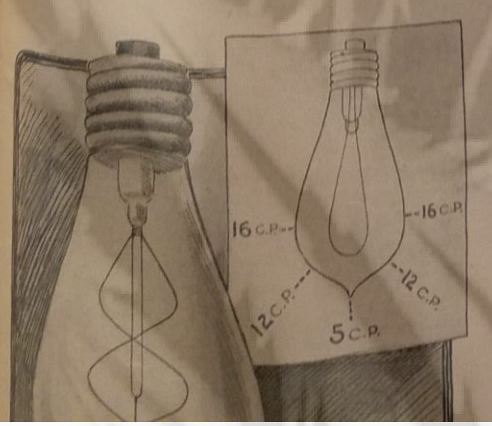
Several patents have recently been issued in the United States to Walther Nernst, Henry N. Potter, and Marshall W. Hanks, for processes and devices designed to overcome various defects which have been noticeable in the Nernst lamp.

Mr. Potter intends to use several spirals of wire to effect the heating of a single glower, or a number of glowers. A single spiral suffices to heat small glowers with sufficient uniformity, but when glowers of large-current capacity are to be started up, the heat must be very evenly distributed to prevent cracking of the glower. Instead of increasing the diameter and length of wire of a small heater, which is rather costly, Mr. Potter finds it cheaper to multiply heaters in parallel. Several heaters equal in surface to a single large heater, he finds, will heat up more quickly, as they have but a fraction of the mass of the large one. Several heaters can be so distributed about a glower that their combined effects heat much more evenly than a single spiral practically can.

The quality possessed by the glowers of acquiring an increased conductivity under the influence of heat has been counterbalanced by the employment of ballast-conductors placed in series with the glowers. But in the practical manufacture of standardized ballast and of glowers having uniform qualities under the conditions of practical use, it is sometimes found that an additional adjustment of the ballast is needed in order to secure perfect working. It is sometimes desirable to employ a ballast inclosed in an air-tight chamber, or so to construct the principal portion of the ballast that it is not readily adjustable. Mr. Nernst has devised a divided ballast, a portion of which is standardized as perfectly as possible, while the remainder is adjusted according to the peculiar conditions of each glower. By the employment of the divided ballast it is possible to compensate for any imperfection in the standardized ballast or in the glower, or both.

Mr. Nernst has likewise invented four compositions for glowers. These compositions consist essentially of the oxide of zirconium mixed with earths of the yttrium or cerium groups.

An effective and easily practised method for treating Nernst lamp glowers whereby they may be adapted to circuits of a given voltage, is the subject of the patent granted to Mr. Hanks. The adaptability



... material which ... them in a heated ... powder while hot and is rotated during treatm... the glower body itself. If the glo... treatment will be deposited in a uniform layer. ... across the circuit is continued until a voltmeter, conn... ing the glower from which the energy for ... increase in cross-section has been obtained.

THREE NEW ELECTRICAL DEVICES.

The matter of rating the efficiency of an el... lamp of the incandescent type is always difficu... the reason that the glow is found to vary greatly

SPRING-ROLLER LAMP HANGER

the readings are taken at different point... of the variable distribution of the light... form of illumination could never be rega... tirely faultless. What is known as th... filament, the first form ever used, varied ... in its illumination on the horizontal pl... was sadly deficient in its vertical distribu... small percentage of its maximum candle ... thrown directly down through the tip. ... step forward was the single loop, whi... effect of increasing the amount of li... through the tip end of the bulb; but the... tribution was much more irregular th... "hairpin" filament. Following these wer... filament, the anchored coil, and the dou... filament, the standard set... none of these reached the standard set... addition to the assortment of bulbs on t... one with a spiral filament, which is s... accompanying cut beside a "hairpin" fi... spiral design is said to give the max... power at every point on the vertical a... horizontal plane.

... is often necessary to shift the positi... One man likes his lig... work as it ...

SIXTY-SEVENTH YEAR

SCIENTIFIC AMERICAN

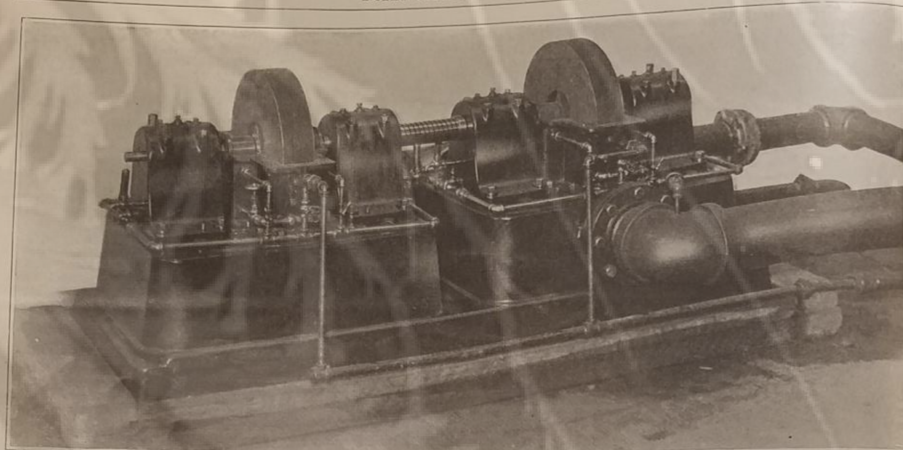
THE WEEKLY JOURNAL OF PRACTICAL INFORMATION

VOLUME CV.
NUMBER 14.

NEW YORK, SEPTEMBER 30, 1911

10 CENTS A COPY
$3.00 A YEAR

THE GREATEST VIADUCT OF EUROPE—SITTER, SWITZERLAND. [See page 293.]



The top half of casings is removed, showing two rotors. Each rotor consists of 25 disks 1/32-inch thick by 18 inch diameter. The steam enters at the periphery, and flows in spiral paths to exhaust at the center of the disks. The driving turbine is to the left, the brake turbine to the right. Between them is a torsion spring. The steam inlets are on opposite sides on the two rotors; the driving rotor moving clockwise. The torsion of the spring is automatically shown by beams of light and mirrors and the horse-power is read off a scale. At 9,000 revolutions per minute, with 125 pounds at the throttle and free exhaust, this turbine develops 200 horse-power. It weighs two pounds per horse-power.

The Tesla turbine testing plant at the Edison Waterside Station, New York.

The Tesla Steam Turbine

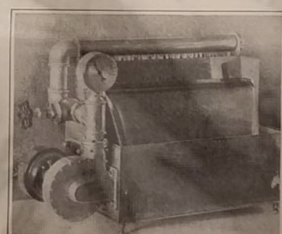
The Rotary Heat Motor Reduced to Its Simplest Terms

IT will interest the readers of the SCIENTIFIC AMERICAN to know that Nikola Tesla, whose reputation must, naturally, stand upon the contributions he made to electrical engineering when the art was yet in its comparative infancy, is by training and choice a mechanical engineer, with a strong leaning to that branch of it which is covered by the term "steam engineering." For several years past he has devoted much of his attention to improvements in thermo-dynamic conversion, and the result of his theories and practical experiments is to be found in an entirely new form of prime movers shown in operation at the Waterside station of the New York Edison Company, who kindly placed the facilities of their great plant at his disposal for carrying on experimental work.

By the courtesy of the inventor, we are enabled to publish the accompanying views, representing the testing plant at the Waterside station, which are the first photographs of this interesting motor that have yet been made public.

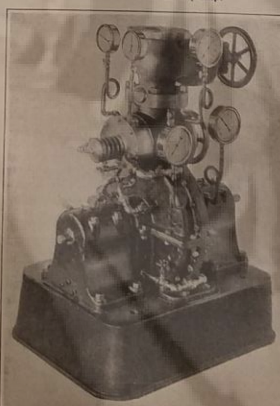
The basic principle which determined Tesla's investigations was the well-known fact that when a fluid (steam, gas or water) is used as a vehicle of energy, the highest possible economy can be obtained only when the changes in velocity and direction of the movement of the fluid are made as gradual and easy as possible. In the present forms of turbines in which the energy is transmitted by pressure, reaction or impact, as in the De Laval, Parsons, and Curtiss types, more or less sudden changes both of speed and direction are involved, with consequent shocks, vibration and destructive eddies. Furthermore, the introduction of pistons, blades, buckets, and intercepting devices of this general class, into the path of the fluid involves much delicate and difficult mechanical construction which adds greatly to the cost both of production and maintenance.

The desiderata in an ideal turbine group themselves under the heads of the theoretical and the mechanical. The theoretically perfect turbine would be one in which the fluid was so controlled from the inlet to the exhaust that its energy was delivered to the driving shaft with the least possible losses due to the mechanical means employed. The mechanically perfect turbine would be one which combined simplicity and cheapness of construction, durability, ease and rapidity of repairs, and a small ratio of weight and space occupied to the power delivered on the shaft. Mr. Tesla maintains that in the turbine which forms the subject of this article, he has carried the steam and gas motor a long step forward toward the maximum attainable efficiency, both theoretical and mechanical. That these claims are well founded is shown by the fact that in the plant at the Edison station, he is securing an



This little pump, driven by a motor of 1/12 horse-power, is here shown delivering 40 gallons of water per minute against a 9-foot head.

The turbine used as a pump.



This view shows one complete high pressure unit, with the steam throttle above, and below it the reversing valve and the compact turbine. Note the many gages used in the tests.

A 200-horse-power high-pressure turbine.

output of 200 horse-power from a single-stage steam turbine with atmospheric exhaust, weighing less than 2 pounds per horse-power, which is contained within a space measuring 2 feet by 3 feet, by 2 feet in height, and which accomplishes these results with a thermal fall of only 130 B.T.U., that is, about one-third of the total drop available. Furthermore, considered from the mechanical standpoint, the turbine is astonishingly simple and economical in construction, and by the very nature of its construction, should prove to possess such a durability and freedom from wear and breakdown as to place it, in these respects, far in advance of any type of steam or gas motor of the present day.

Briefly stated, Tesla's steam motor consists of a set of flat steel disks mounted on a shaft and rotating within a casing, the steam entering with high velocity at the periphery of the disks, flowing between them in free spiral paths, and finally escaping through exhaust ports at their center. Instead of developing the energy of the steam by pressure, reaction, or impact, on a series of blades or vanes, Tesla depends upon the fluid properties of adhesion and viscosity—the attraction of the steam to the faces of the disks and the resistance of its particles to molecular separation combining in transmitting the velocity energy of the motive fluid to the plates and the shaft.

By reference to the accompanying photographs and line drawings, it will be seen that the turbine has a rotor *A* which in the present case consists of 25 flat steel disks, one thirty-second of an inch in thickness, of hardened and carefully tempered steel. The rotor as assembled is 3½ inches wide on the face, by 18 inches in diameter, and when the turbine is running at its maximum working velocity, the material is never under a tensile stress exceeding 50,000 pounds per square inch. The rotor is mounted in a casing *D*, which is provided with two inlet nozzles, *B* for use in running direct and *B'* for reversing. Openings *C* are cut out at the central portion of the disks and these communicate directly with exhaust ports formed in the side of the casing.

In operation, the steam, or gas, as the case may be, is directed on the periphery of the disks through the nozzle *B* (which may be diverging, straight or converging), where more or less of its expansive energy is converted into velocity energy. When the machine is at rest, the radial and tangential forces due to the pressure and velocity of the steam cause it to travel in a rather short curved path toward the central exhaust opening, as indicated by the full black line in the accompanying diagram; but as the disks commence to rotate and their speed increases, the steam travels in spiral paths the length of which increases until, as

Property of

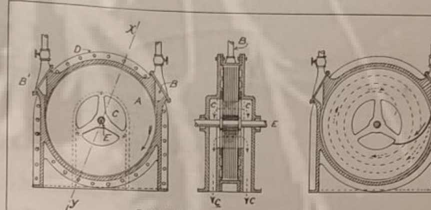
in the case of the present turbine, the particles of the fluid complete a number of turns around the shaft before reaching the exhaust, covering in the meantime a lineal path some 12 to 16 feet in length. During its progress from inlet to exhaust, the velocity and pressure of the steam are reduced until it leaves the exhaust at 1 or 2 pounds gage pressure.

The resistance to the passage of the steam or gas between adjoining plates is approximately proportionate to the square of the relative speed, which is at a maximum toward the center of the disks and is equal to the tangential velocity of the steam. Hence the resistance to radial escape is very great, being furthermore enhanced by the centrifugal force acting outwardly. One of the most desirable elements in a perfected turbine is that of reversibility, and we are all familiar with the many and frequently cumbersome means which have been employed to secure this end. It will be seen that this turbine is admirably adapted for reversing, since this effect can be secured by merely closing the right-hand valve and opening that on the left.

It is evident that the principles of this turbine are equally applicable, by slight modifications of design, for its use as a pump, and we present a photograph of a demonstration model which is in operation in Mr. Tesla's office. This little pump, driven by an electric motor of 1/12 horse-power, delivers 40 gallons per minute against a head of 9 feet. The discharge pipe leads up to a horizontal tube provided with a wire mesh for screening the water and checking the eddies. The water falls through a slot in the bottom of this tube and after passing below a baffle plate flows in a steady stream about ¾ inch thick by 18 inches in width, to a trough from which it returns to the pump. Pumps of this character show an efficiency favorably comparing with that of centrifugal pumps and they have the advantage that great heads are obtainable economically in a single stage. The runner is mounted in a two-part volute casing and except for the fact that the place of the buckets, vanes, etc., of the ordinary centrifugal pump is taken by a set of disks, the construction is generally similar to that of pumps of the standard kind.

In conclusion, it should be noted that although the experimental plant at the Waterside station develops 200 horse-power with 125 pounds at the supply pipe and free exhaust, it could show an output of 300 horse-power with the full pressure of the Edison supply circuit. Furthermore, Mr. Tesla states that if it were compounded and the exhaust were led to a low pressure unit, carrying about three times the number of disks contained in the high pressure element, with connection to a condenser affording 28½ to 29 inches of vacuum, the results obtained in the present high-pressure machine indicate that the compound unit would give an output of 600 horse-power, without great increase of dimensions. This estimate is conservative.

The testing plant consists of two identical turbines connected by a carefully calibrated torsion spring, the machine to the left being the driving element, the other the brake. In the brake element, the steam is delivered to the blades in a direction opposite to that of the rotation of the disks. Fastened to the shaft of the brake turbine is a hollow pulley provided with two diametrically opposite narrow slots, and an incandescent lamp placed inside close to the rim. As the pulley rotates, two flashes of light pass out of the same, and by means of reflecting mirrors and lenses, they are carried around the plant and fall upon two rotating glass mirrors placed back to back on the shaft of the driving turbine so that the center line of the silver coatings coincides with the axis of the shaft. The mirrors are so set that when there is no torsion on the spring, the light beams produce a luminous spot stationary at the zero of the scale. But as soon as load is put on, the beam is deflected through an angle which indicates directly the torsion. The scale and spring are so proportioned and adjusted that the horse-power can be read directly from the deflections noted. The indications of this device are very accurate and have shown that when the turbine is running at 9,000 revolutions under an inlet pressure of 125 pounds to the square inch, and with free exhaust, 200 brake horse-power are developed. The consumption under these conditions of maximum output is 38 pounds of saturated steam per horse-power per hour—a very high efficiency when we consider that the heat-drop, measured by thermometers, is only 130 B.T.U., and that the energy transformation is effected in one stage. Since about three times this number of heat units are available in a modern plant with superheat and high vacuum, the above means a consumption of less than 12 pounds per horse-power hour in such turbines adapted to take up the full drop. Under certain conditions, however, very high thermal efficiencies have been obtained which demonstrate that in large machines based on this principle, in which a very small slip can be secured, the steam consumption will be much lower and should, Mr. Tesla states, approximate the theoretical minimum, thus resulting in nearly frictionless turbine transmitting almost the entire expansive energy of the steam to the shaft.



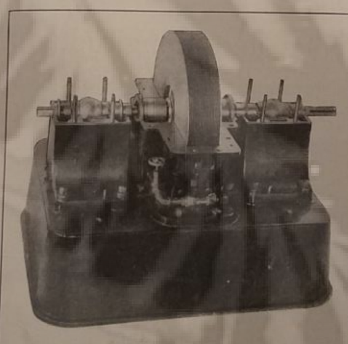
Sectional views.

Spiral path of steam.

Details of turbine.

Some Striking Coal Facts

LAST year the United States mined 501,596,378 short tons of coal or nearly two-fifths of the year's total production for the world. This coal would load a train stretching back and forth across the United States from the Atlantic to the Pacific 33 times—a train approximately 100,000 miles long. Eleven years ago the United States for the first time surpassed Great Britain with a production of 253,741,192 tons, only a little more than half of last year's output. The mere increase of the coal output of the United States for 1910 over that of 1909—40,781,762 tons—was greater than the total production of any foreign country except Great Britain, Germany, Austria, Hungary, or France.



This turbine, whose rotor consists simply of a set of flat disks 18 inches in diameter, develops 200 brake horse-power on test.

Turbine with upper half of casing removed.

This increase alone was one and one-fifth times as great as the entire production of the United States in 1870. Excepting only Great Britain and Germany, either of the States of Pennsylvania or West Virginia produced in 1910 more coal than any foreign country. For the past seven or eight 10-year periods the coal production for each decade has been about equal to the entire amount of coal previously mined in the United States. Thus in the 10 years between 1885 and 1895 the production was 1,586,098,641 tons, while the entire amount of coal mined prior to 1895 was only 1,552,080,478 tons. In the 10 years betweeen 1895 and 1905 the production was 2,832,402,746 tons, while all the coal which had been mined prior to 1895 was 3,138,174,119 tons.

Incredible as it may seem, at the present rate of increase the ten-year period between 1905 and 1915 will show a production greater than all the coal mined in the United States prior to 1905. In 1850 the per capita production of coal was a little over one-fourth of a ton. In 1870 the per capita production had increased to nearly one ton; in 1890 it was 2½ tons; in 1900 it was 3½ tons, and in 1910 with the population of 91,972,266 the production was nearly 5½ tons for each person.

Last year 725,030 men mined coal in the United States. The great coal production record of 1910 was made in spite of a series of labor strikes participated in by 215,640 men. The loss in wages alone amounted to nearly $30,000,000.

The quantity of coal used for making coke in the United States for metallurgical purposes was 52,187,450 tons. This is additional to by-product coke produced in gas manufacture.

The total production of coal in the United States at the close of 1910 was 8,243,351,259 short tons. This plus the estimated loss incident to mining makes a total exhaustion of 13,395,000,000 tons. The United States Geological Survey estimates the original supply of coal in the ground in the United States, exclusive of Alaska, at 3,076,204,000,000 tons. This original supply less the exhaustion at the close of 1910 leaves an apparent supply still available of 3,062,808,972,000 tons, or 99.6 per cent of the original supply. In other words, in all the time since coal mining began in the United States the draft upon the original supply including loss in mining, has amounted to less than one-half of one per cent. At the present rate of production of approximately half a billion tons a year the coal reserve of the United States would therefore last 6,000 years. At the present rate of increase in production, however, these three thousand billion tons of coal in the ground would last only a few generations.

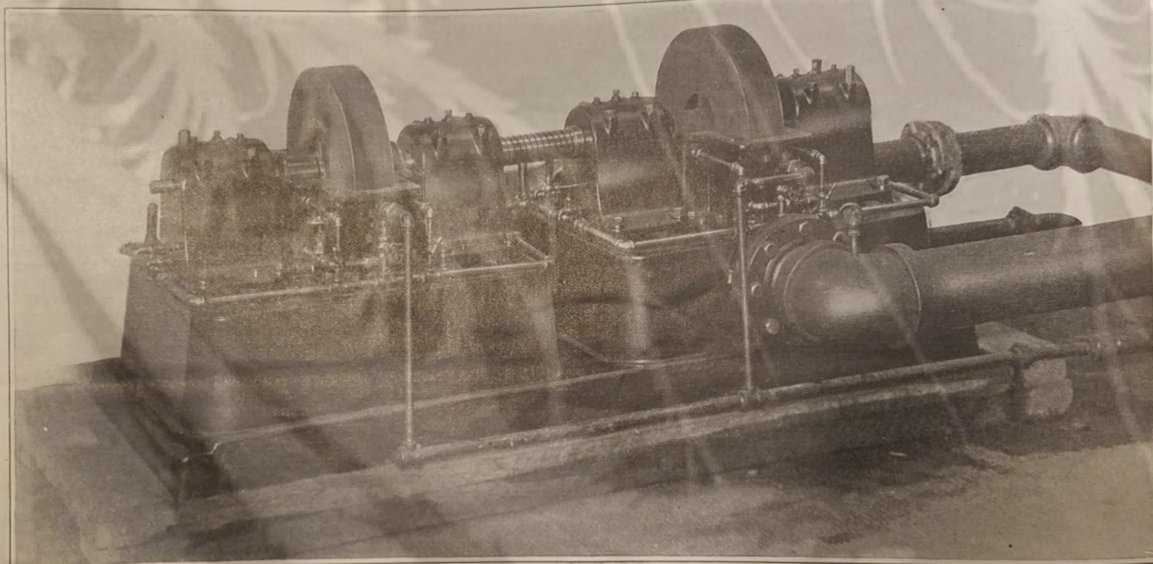
Foreign Students in America

ADDRESSING the House of Representatives on the many new activities of the United States diplomatic service, Representative Foster, of Vermont, late chairman of the House Foreign Affairs Committee, recently called attention to the effort made by our diplomatic and consular representatives to advertise the United States as an educational center, an undertaking that has been fruitful of results.

One of the outcomes of this program was the formation in Buenos Aires two years ago of a United States University Club, which has been the means of sending at least 20 young Argentinians to this country to be educated. Under the auspices of this club lectures are given on university life in the United States, illustrated with a large number of appropriate stereopticon views. Negotiations are now under way for an interchange of schoolboys between the Boston High School of Commerce and the preparatory department of the University of La Plata. There are now at least 400 Latin Americans studying in the United States, and the number is steadily increasing.

Through the efforts of our ambassador at Constantinople, supported by the State Department, Columbia University has voted to receive, free of all tuition charges, three students annually from the Ottoman Empire for the next ten years, to pursue courses of study in any of the departments of the university. These students are to be selected by the Ottoman government, with the advice and approval of the ambassador at Constantinople.

The education of Chinese students in America, a matter in which the United States government has always taken a kindly interest, is assuming ever larger proportions. These students now number between 800 and 900. Half of these are "government students," supported by the different Chinese provinces, and by the remitted portion of the Boxer indemnity fund. To insure that the indemnity students coming to the United States should not start with a serious handicap, but be fully prepared to enter the American colleges, an academy has been established in Peking by the Chinese government, where these students receive preliminary instuctions under American teachers.



The top half of casings is removed, showing two rotors. Each rotor consists of 25 disks 1/32-inch thick by 18 inch diameter. The steam enters at the periphery, and flows in spiral paths to exhaust at the center of the disks. The driving turbine is to the left, the brake turbine to the right. Between them is a torsion spring. The steam inlets are on opposite sides on the two rotors; the driving rotor moving clockwise. The torsion of the spring is automatically shown by beams of light and mirrors and the horse-power is read off a scale. At 9,000 revolutions per minute, with 125 pounds at the throttle and free exhaust, this turbine develops 200 horse-power. It weighs two pounds per horse-power.

The Tesla turbine testing plant at the Edison Waterside Station, New York.

The Tesla Steam Turbine

The Rotary Heat Motor Reduced to Its Simplest Terms

IT will interest the readers of the SCIENTIFIC AMERI-

output of 200 horse-power from a single-stage steam

disks. The driving turbine is to the left, the brake turbine to the right. ... the horse-power is read off a scale. ...
The torsion of the spring is automatically shown by beams of light and mirrors and ... It weighs two pounds per horse-power.
and free exhaust, this turbine develops 200 horse-power.

The Tesla turbine testing plant at the Edison Waterside Station, New York.

The Tesla Steam Turbine

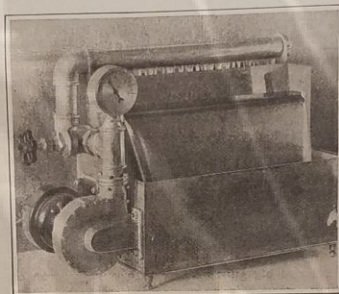
The Rotary Heat Motor Reduced to Its Simplest Terms

IT will interest the readers of the SCIENTIFIC AMERICAN to know that Nikola Tesla, whose reputation must, naturally, stand upon the contributions he made to electrical engineering when the art was yet in its comparative infancy, is by training and choice a mechanical engineer, with a strong leaning to that branch of it which is covered by the term "steam engineering." For several years past he has devoted much of his attention to improvements in thermo-dynamic conversion, and the result of his theories and practical experiments is to be found in an entirely new form of prime movers shown in operation at the Waterside station of the New York Edison Company, who kindly placed the facilities of their great plant at his disposal for carrying on experimental work.

By the courtesy of the inventor, we are enabled to publish the accompanying views, representing the testing plant at the Waterside station, which are the first photographs of this interesting motor that have yet been made public.

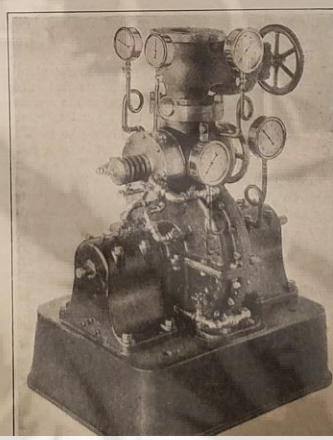
The basic principle which determined Tesla's investigations was the well-known fact that when a fluid (steam, gas or water) is used as a vehicle of energy, the highest possible economy can be obtained only when the changes in velocity and direction of the movement of the fluid are made as gradual and easy as possible. In the present forms of turbines in which the energy is transmitted by pressure, reaction or impact, as in the De Laval, Parsons, and Curtiss types, more or less sudden changes both of speed and direction are involved, with consequent shocks, vibration and destructive eddies. Furthermore, the introduction of pistons, blades, buckets, and intercepting devices of this general class, into the path of the fluid involves much delicate and difficult mechanical construction which adds greatly to the cost both of production and maintenance.

The desiderata in an ideal turbine group themselves under the heads of the theoretical and the mechanical. The theoretically perfect turbine would be one in which the fluid was so controlled from the inlet to the exhaust that its energy was delivered to the driving shaft with the least possible losses due to the mechanical means employed. The mechanically perfect turbine would be one which combined simplicity and cheapness of construction, durability, ease and rapidity of repairs, and a small ratio of weight and space oc-



This little pump, driven by a motor of $\frac{1}{12}$ horse-power, is here shown delivering 40 gallons of water per minute against a 9-foot head.

The turbine used as a pump.



output of 200 horse-power from a single-stage steam turbine with atmospheric exhaust, weighing less than 2 pounds per horse-power, which is contained within a space measuring 2 feet by 3 feet, by 2 feet in height, and which accomplishes these results with a thermal fall of only 130 B.T.U., that is, about one-third of the total drop available. Furthermore, considered from the mechanical standpoint, the turbine is astonishingly simple and economical in construction, and by the very nature of its construction, should prove to possess such a durability and freedom from wear and breakdown as to place it, in these respects, far in advance of any type of steam or gas motor of the present day.

Briefly stated, Tesla's steam motor consists of a set of flat steel disks mounted on a shaft and rotating within a casing, the steam entering with high velocity at the periphery of the disks, flowing between them in free spiral paths, and finally escaping through exhaust ports at their center. Instead of developing the energy of the steam by pressure, reaction, or impact, on a series of blades or vanes, Tesla depends upon the fluid properties of adhesion and viscosity—the attraction of the steam to the faces of the disks and the resistance of its particles to molecular separation combining in transmitting the velocity energy of the motive fluid to the plates and the shaft.

By reference to the accompanying photographs and line drawings, it will be seen that the turbine has a rotor *A* which in the present case consists of 25 flat steel disks, one thirty-second of an inch in thickness, of hardened and carefully tempered steel. The rotor as assembled is 3½ inches wide on the face, by 18 inches in diameter, and when the turbine is running at its maximum working velocity, the material is never under a tensile stress exceeding 50,000 pounds per square inch. The rotor is mounted in a casing *D*, which is provided with two inlet nozzles, *B* for use in running direct and *B'* for reversing. Openings *C* are cut out at the central portion of the disks and these communicate directly with exhaust ports formed in the side of the casing.

In operation, the steam, or gas, as the case may be, is directed on the periphery of the disks through the nozzle *B* (which may be diverging, straight or converging), where more or less of its expansive energy is converted into velocity energy. When the machine

The top half of casings is removed, showing two rotors. Each rotor consists of 25 disks $\frac{1}{32}$-inch thick by ... The steam inlets are on opp... At 9,000 revolutions per minute, ...
disks. The driving turbine is to the left, the brake turbine to the right. Between them is a torsion spring. The torsion of the spring is automatically shown by beams of light and mirrors and the horse-power is read off a scale.
... and free exhaust, this turbine develops 200 horse-power. It weighs two pounds per horse-power.

The Tesla turbine testing plant at the Edison Waterside Station, New York.

The Tesla Steam Turbine

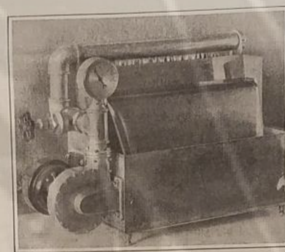
The Rotary Heat Motor Reduced to Its Simplest Terms

IT will interest the readers of the SCIENTIFIC AMERICAN to know that Nikola Tesla, whose reputation must, naturally, stand upon the contributions he made to electrical engineering when the art was yet in its comparative infancy, is by training and choice a mechanical engineer, with a strong leaning to that branch of it which is covered by the term "steam engineering." For several years past he has devoted much of his attention to improvements in thermo-dynamic conversion, and the result of his theories and practical experiments is to be found in an entirely new form of prime movers shown in operation at the Waterside station of the New York Edison Company, who kindly placed the facilities of their great plant at his disposal for carrying on experimental work.

By the courtesy of the inventor, we are enabled to publish the accompanying views, representing the testing plant at the Waterside station, which are the first photographs of this interesting motor that have yet been made public.

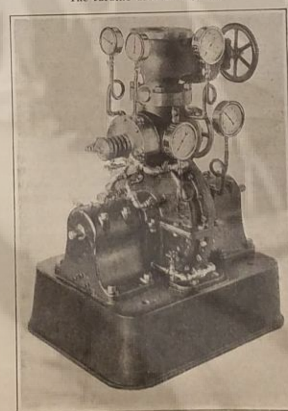
The basic principle which determined Tesla's investigations was the well-known fact that when a fluid (steam, gas or water) is used as a vehicle of energy, the highest possible economy can be obtained only when the changes in velocity and direction of the movement of the fluid are made as gradual and easy as possible. In the present forms of turbines in which the energy is transmitted by pressure, reaction or impact, as in the De Laval, Parsons, and Curtiss types, more or less sudden changes both of speed and direction are involved, with consequent shocks, vibration and destructive eddies. Furthermore, the introduction of pistons, blades, buckets, and intercepting devices of this general class, into the path of the fluid involves much delicate and difficult mechanical construction which adds greatly to the cost both of production and maintenance.

The desiderata in an ideal turbine group themselves under the heads of the theoretical and the mechanical. The theoretically perfect turbine would be one in which the fluid was so controlled from the inlet to the exhaust that its energy was delivered to the driving shaft with the least possible losses due to the mechanical means employed. The mechanically perfect turbine would be one which combined simplicity and cheapness of construction, durability, ease and rapidity of repairs, and a small ratio of weight and space occupied to the power delivered on the shaft. Mr. Tesla maintains that in the turbine which forms the subject of this article, he has carried the steam and gas motor a long step forward toward the maximum attainable efficiency, both theoretical and mechanical. That these claims are well founded is shown by the fact that in the plant at the Edison station, he is securing an output of 200 horse-power from a single-stage steam turbine with atmospheric exhaust, weighing less than 2 pounds per horse-power, which is contained within a space measuring 2 feet by 3 feet, by 2 feet in height, and which accomplishes these results with a thermal fall of only 130 B.T.U., that is, about one-third of the total drop available. Furthermore, considered from the mechanical standpoint, the turbine is astonishingly simple and economical in construction, and by the very nature of its construction, should prove to possess such a durability and freedom from wear and breakdown as to place it, in these respects, far in advance of any type of steam or gas motor of the present day.



This little pump, driven by a motor of $\frac{1}{12}$ horse-power, is here shown delivering 40 gallons of water per minute against a 9-foot head.

The turbine used as a pump.



This view shows one complete high pressure unit, with the steam throttle above, and below it the reversing valve and the compact turbine. Note the many gages used in the tests.

A 200-horse-power high-pressure turbine.

Briefly stated, Tesla's steam motor consists of a set of flat steel disks mounted on a shaft and rotating within a casing, the steam entering with high velocity at the periphery of the disks, flowing between them in free spiral paths, and finally escaping through exhaust ports at their center. Instead of developing the energy of the steam by pressure, reaction, or impact, on a series of blades or vanes, Tesla depends upon the fluid properties of adhesion and viscosity—the attraction of the steam to the faces of the disks and the resistance of its particles to molecular separation combining in transmitting the velocity energy of the motive fluid to the plates and the shaft.

By reference to the accompanying photographs and line drawings, it will be seen that the turbine has a rotor *A* which in the present case consists of 25 flat steel disks, one thirty-second of an inch in thickness, of hardened and carefully tempered steel. The rotor as assembled is 3½ inches wide on the face, by 18 inches in diameter, and when the turbine is running at its maximum working velocity, the material is never under a tensile stress exceeding 50,000 pounds per square inch. The rotor is mounted in a casing *D*, which is provided with two inlet nozzles, *B* for use in running direct and *B'* for reversing. Openings *C* are cut out at the central portion of the disks and these communicate directly with exhaust ports formed in the side of the casing.

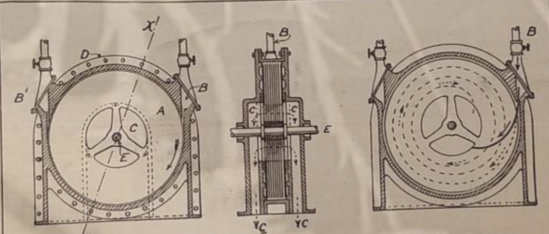
In operation, the steam, or gas, as the case may be, is directed on the periphery of the disks through the nozzle *B* (which may be diverging, straight or converging), where more or less of its expansive energy is converted into velocity energy. When the machine is at rest, the radial and tangential forces due to the pressure and velocity of the steam cause it to travel in a rather short curved path toward the central exhaust opening, as indicated by the full black line in the accompanying diagram; but as the disks commence to rotate and their speed increases, the steam travels in spiral paths the length of which increases until, as

in the case of the present turbine, the particles of the fluid complete a number of turns around the shaft before reaching the exhaust, covering in the meantime a lineal path some 12 to 16 feet in length. During its progress from inlet to exhaust, the velocity and pressure of the steam are reduced until it leaves the exhaust at 1 or 2 pounds gage pressure.

The resistance to the passage of the steam or gas between adjoining plates is approximately proportionate to the square of the relative speed, which is at a maximum toward the center of the disks and is equal to the tangential velocity of the steam. Hence the resistance to radial escape is very great, being furthermore enhanced by the centrifugal force acting outwardly. One of the most desirable elements in a perfected turbine is that of reversibility, and we are all familiar with the many and frequently cumbersome means which have been employed to secure this end. It will be seen that this turbine is admirably adapted for reversing, since this effect can be secured by merely closing the right-hand valve and opening that on the left.

It is evident that the principles of this turbine are equally applicable, by slight modifications of design, for its use as a pump, and we present a photograph of a demonstration model which is in operation in Mr. Tesla's office. This little pump, driven by an electric motor of 1/12 horse-power, delivers 40 gallons per minute against a head of 9 feet. The discharge pipe leads up to a horizontal tube provided with a wire mesh for screening the water and checking the eddies. The water falls through a slot in the bottom of this tube and a'ter passing below a baffle plate flows in a steady stream about ¾ inch thick by 18 inches in width, to a trough from which it returns to the pump. Pumps of this character show an efficiency favorably comparing with that of centrifugal pumps and they have the advantage that great heads are obtainable economically in a single stage. The runner is mounted in a two-part volute casing and except for the place of the buckets, vanes, etc., of the

high efficiency when we consider that the heat-drop, measured by thermometers, is only 130 B.T.U., and that the energy transformation is effected in one stage. Since about three times this number of heat units are available in a modern plant with superheat and high vacuum, the above means a consumption of less than 12 pounds per horse-power hour in such turbines adapted to take up the full drop. Under certain conditions, however, very high thermal efficiencies have been obtained which demonstrate that in large machines based on this principle, in which a very small slip can be secured, the steam consumption will be much lower and should, Mr. Tesla states, approximate the theoretical minimum, thus resulting in nearly frictionless turbine transmitting almost the entire expansive energy of the steam to the shaft.



Sectional views. Spiral path of steam.

Details of turbine.

Some Striking Coal Facts

LAST year the United States mined 501,596,378 short tons of coal or nearly two-fifths of the year's total production for the world. This coal would load a train stretching back and forth across the United States from the Atlantic to the Pacific 33 times—a train approximately 100,000 miles long. Eleven years ago the United States for the first time surpassed Great Britain with a production of 253,741,192 tons,

while all the coal which had been mined prior to 1895 was 3,138,174,119 tons.

Incredible as it may seem, at the present rate of increase the ten-year period between 1905 and 1915 will show a production greater than all the coal mined in the United States prior to 1905. In 1850 the per capita production of coal was a little over one-fourth of a ton. In 1870 the per capita production had increased to nearly one ton; in 1890 it was 2½ tons; in 1900 it was 3½ tons, and in 1910 with the population of 91,972,266 the production was nearly 5½ tons for each person.

Last year 725,030 men mined coal in the United States. The great coal production record of 1910 was made in spite of a series of labor strikes participated in by 215,640 men. The loss in wages alone amounted to nearly $30,000,000.

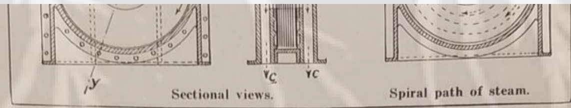
The quantity of coal used for making coke in the United States for metallurgical purposes was 52,187,450 tons. This is additional to by-product coke produced in gas manufacture.

The total production of coal in the United States at the close of 1910 was 8,243,351,259 short tons. This plus the estimated loss incident to mining makes a total exhaustion of 13,395,000,000 tons. The United States Geological Survey estimates the original supply of coal in the ground in the United States, exclusive of Alaska, at 3,076,204,000,000 tons. This original supply less the exhaustion at the close of 1910 leaves an apparent supply still available of 3,062,808,972,000 tons, or 99.6 per cent of the original supply. In other words, in all the time since coal mining began in the United States the draft upon the original supply including loss in mining, has amounted to less than one-half of one per cent. At the present rate of production of approximately half a billion tons a year the coal reserve of the United States would therefore last 6,000 years. At the present rate of increase in production, however, these three thousand billion tons of coal in the ground would last only a few generations.

this turbine are equally applicable, by slight modifications of design, for its use as a pump, and we present a photograph of a demonstration model which is in operation in Mr. Tesla's office. This little pump, driven by an electric motor of 1/12 horse-power, delivers 40 gallons per minute against a head of 9 feet. The discharge pipe leads up to a horizontal tube provided with a wire mesh for screening the water and checking the eddies. The water falls through a slot in the bottom of this tube and after passing below a baffle plate flows in a steady stream about ¾ inch thick by 18 inches in width, to a trough from which it returns to the pump. Pumps of this character show an efficiency favorably comparing with that of centrifugal pumps and they have the advantage that great heads are obtainable economically in a single stage. The runner is mounted in a two-part volute casing and except for the fact that the place of the buckets, vanes, etc., of the ordinary centrifugal pump is taken by a set of disks, the construction is generally similar to that of pumps of the standard kind.

In conclusion, it should be noted that although the experimental plant at the Waterside station develops 200 horse-power with 125 pounds at the supply pipe and free exhaust, it could show an output of 300 horse-power with the full pressure of the Edison supply circuit. Furthermore, Mr. Tesla states that if it were compounded and the exhaust were led to a low pressure unit, carrying about three times the number of disks contained in the high pressure element, with connection to a condenser affording 28½ to 29 inches of vacuum, the results obtained in the present high-pressure machine indicate that the compound unit would give an output of 600 horse-power, without great increase of dimensions. This estimate is conservative.

The testing plant consists of two identical turbines connected by a carefully calibrated torsion spring, the machine to the left being the driving element, the other the brake. In the brake element, the steam is delivered to the blades in a direction opposite to that of the rotation of the disks. Fastened to the shaft of the brake turbine is a hollow pulley provided with two diametrically opposite narrow slots, and an incandescent lamp placed inside close to the rim. As the pulley rotates, two flashes of light pass out of the same, and by means of reflecting mirrors and lenses, they are carried around the plant and fall upon two rotating glass mirrors placed back to back on



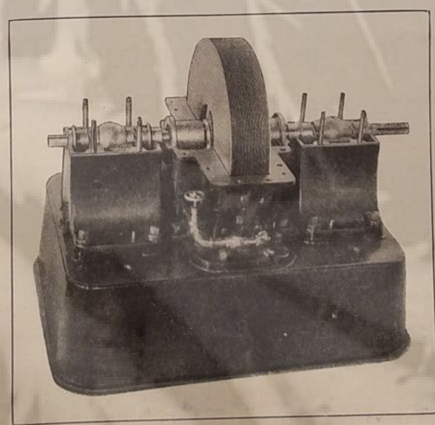
Sectional views. Spiral path of steam.

Details of turbine.

bine transmitting almost the entire expansive energy of the steam to the shaft.

Some Striking Coal Facts

LAST year the United States mined 501,596,378 short tons of coal or nearly two-fifths of the year's total production for the world. This coal would load a train stretching back and forth across the United States from the Atlantic to the Pacific 33 times—a train approximately 100,000 miles long. Eleven years ago the United States for the first time surpassed Great Britain with a production of 253,741,192 tons, only a little more than half of last year's output. The mere increase of the coal output of the United States for 1910 over that of 1909—40,781,762 tons—was greater than the total production of any foreign



This turbine, whose rotor consists simply of a set of flat disks 18 inches in diameter, develops 200 brake horse-power on test.

Turbine with upper half of casing removed.

plus the estimated loss incident to mining makes a total exhaustion of 13,395,000,000 tons. The United States Geological Survey estimates the original supply of coal in the ground in the United States, exclusive of Alaska, at 3,076,204,000,000 tons. This original supply less the exhaustion at the close of 1910 leaves an apparent supply still available of 3,062,808,972,000 tons, or 99.6 per cent of the original supply. In other words, in all the time since coal mining began in the United States the draft upon the original supply including loss in mining, has amounted to less than one-half of one per cent. At the present rate of production of approximately half a billion tons a year the coal reserve of the United States would therefore last 6,000 years. At the present rate of increase in production, however, these three thousand billion tons of coal in the ground would last only a few generations.

Foreign Students in America

ADDRESSING the House of Representatives on the many new activities of the United States diplomatic service, Representative Foster, of Vermont, late chairman of the House Foreign Affairs Committee, recently called attention to the effort made by our diplomatic and consular representatives to advertise the United States as an educational center, an undertaking that has been fruitful of results.

One of the outcomes of this program was the formation in Buenos Aires two years ago of a United States University Club, which has been the means of sending at least 20 young Argentinians to this country to be educated. Under the auspices of this club lectures are given on university life in the United States, illustrated with a large number of appropriate stereopticon views. Negotiations are now under way for an interchange of schoolboys between the Boston High School of Commerce and the preparatory department of the University of La Plata. There are now at least 400 Latin Americans studying in the United States, and the number is steadily increasing.

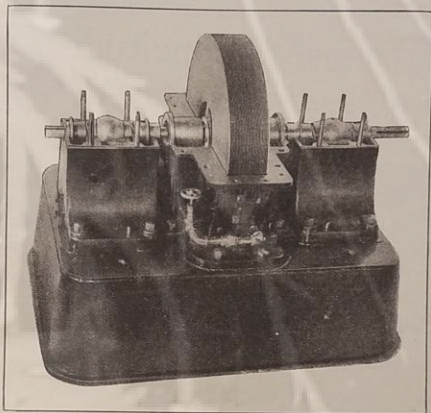
Through the efforts of our ambassador at Constantinople, supported by the State Department, Columbia University has voted to receive, free of all tuition charges, three students annually from the Ottoman Empire for the next ten years, to pursue courses of study in any of the departments of the university. These students are to be selected by the Ottoman government with the advice and approval

[illegible] tainable economically in a single stage. [illegible] heads are ob- mounted in a two-part volute casing and except for the fact that the place of the buckets, vanes, etc., of the ordinary centrifugal pump is taken by a set of disks, the construction is generally similar to that of pumps of the standard kind.

In conclusion, it should be noted that although the experimental plant at the Waterside station develops 200 horse-power with 125 pounds at the supply pipe and free exhaust, it could show an output of 300 horse-power with the full pressure of the Edison supply circuit. Furthermore, Mr. Tesla states that if it were compounded and the exhaust were led to a low pressure unit, carrying about three times the number of disks contained in the high pressure element, with connection to a condenser affording 28½ to 29 inches of vacuum, the results obtained in the present high-pressure machine indicate that the compound unit would give an output of 600 horse-power, without great increase of dimensions. This estimate is conservative.

The testing plant consists of two identical turbines connected by a carefully calibrated torsion spring, the machine to the left being the driving element, the other the brake. In the brake element, the steam is delivered to the blades in a direction opposite to that of the rotation of the disks. Fastened to the shaft of the brake turbine is a hollow pulley provided with two diametrically opposite narrow slots, and an incandescent lamp placed inside close to the rim. As the pulley rotates, two flashes of light pass out of the same, and by means of reflecting mirrors and lenses, they are carried around the plant and fall upon two rotating glass mirrors placed back to back on the shaft of the driving turbine so that the center line of the silver coatings coincides with the axis of the shaft. The mirrors are so set that when there is no torsion on the spring, the light beams produce a luminous spot stationary at the zero of the scale. But as soon as load is put on, the beam is deflected through an angle which indicates directly the torsion. The scale and spring are so proportioned and adjusted that the horse-power can be read directly from the deflections noted. The indications of this device are very accurate and have shown that when the turbine is running at 9,000 revolutions under an inlet pressure of 125 pounds to the square inch, and with free exhaust, 200 brake horse-power are developed. The consumption under these conditions of maximum output is 38 pounds of saturated steam per horse-power per hour—a very

a train stretching back and forth across the United States from the Atlantic to the Pacific 33 times—a train approximately 100,000 miles long. Eleven years ago the United States for the first time surpassed Great Britain with a production of 253,741,192 tons, only a little more than half of last year's output. The mere increase of the coal output of the United States for 1910 over that of 1909—40,781,762 tons—was greater than the total production of any foreign



This turbine, whose rotor consists simply of a set of flat disks 18 inches in diameter, develops 200 brake horse-power on test.

Turbine with upper half of casing removed.

country except Great Britain, Germany, Austria, Hungary, or France.

This increase alone was one and one-fifth times as great as the entire production of the United States in 1870. Excepting only Great Britain and Germany, either of the States of Pennsylvania or West Virginia produced in 1910 more coal than any foreign country. For the past seven or eight 10-year periods the coal production for each decade has been about equal to the entire amount of coal previously mined in the United States. Thus in the 10 years between 1885 and 1895 the production was 1,586,098,641 tons, while the entire amount of coal mined prior to 1895 was only 1,552,080,478 tons. In the 10 years betweeen 1895 and 1905 the production was 2,832,402,746 tons,

the coal reserve of the United States would therefore last 6,000 years. At the present rate of increase in production, however, these three thousand billion tons of coal in the ground would last only a few generations.

Foreign Students in America

ADDRESSING the House of Representatives on the many new activities of the United States diplomatic service, Representative Foster, of Vermont, late chairman of the House Foreign Affairs Committee, recently called attention to the effort made by our diplomatic and consular representatives to advertise the United States as an educational center, an undertaking that has been fruitful of results.

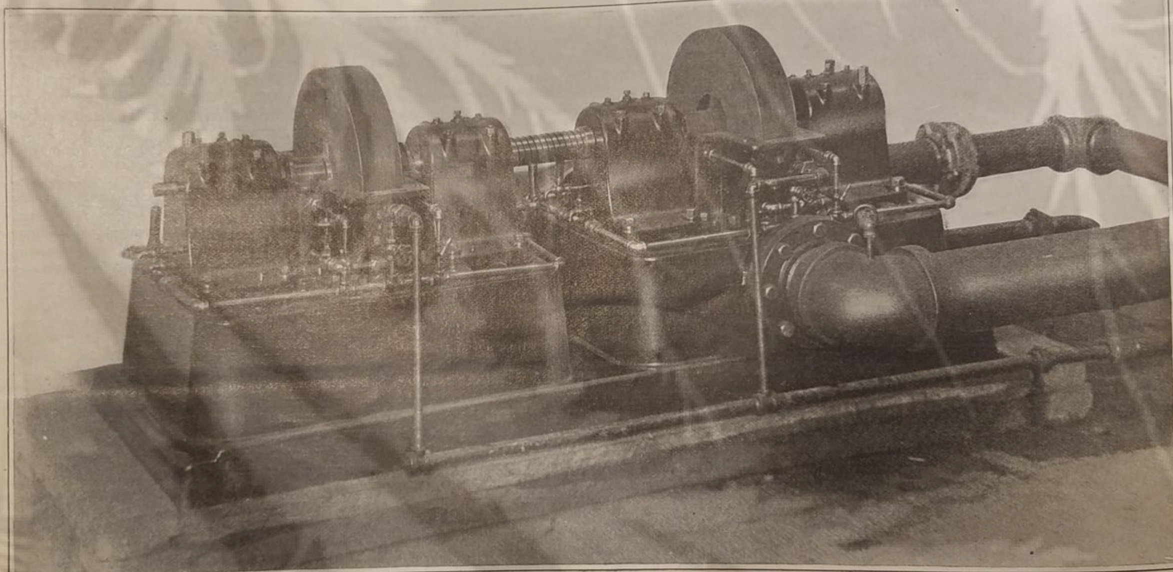
One of the outcomes of this program was the formation in Buenos Aires two years ago of a United States University Club, which has been the means of sending at least 20 young Argentinians to this country to be educated. Under the auspices of this club lectures are given on university life in the United States, illustrated with a large number of appropriate stereopticon views. Negotiations are now under way for an interchange of schoolboys between the Boston High School of Commerce and the preparatory department of the University of La Plata. There are now at least 400 Latin Americans studying in the United States, and the number is steadily increasing.

Through the efforts of our ambassador at Constantinople, supported by the State Department, Columbia University has voted to receive, free of all tuition charges, three students annually from the Ottoman Empire for the next ten years, to pursue courses of study in any of the departments of the university. These students are to be selected by the Ottoman government, with the advice and approval of the ambassador at Constantinople.

The education of Chinese students in America, a matter in which the United States government has always taken a kindly interest, is assuming ever larger proportions. These students now number between 800 and 900. Half of these are "government students," supported by the different Chinese provinces, and by the remitted portion of the Boxer indemnity fund. To insure that the indemnity students coming to the United States should not start with a serious handicap, but be fully prepared to enter the American colleges, an academy has been established in Peking by the Chinese government, where these students receive preliminary instuctions under American teachers.

... economically done. The same time the work can in this particular process is alternating, and the action does not therefore at all partake of the nature of ... is a pure smelting ...

... the peculiar differences that exist under certain ... fact in electrical action, that is, stances between positive and ... is a pity that Mr. ...



The top half of casings is removed, showing two rotors. Each rotor consists of 25 disks ⅜-inch thick by 18 inch diameter. The steam enters at the periphery, and flows in spiral paths to exhaust at the center of the disks. The driving turbine is to the left, the brake turbine to the right. Between them is a torsion spring. The steam inlets are on opposite sides on the two rotors; the driving rotor moving clockwise. The torsion of the spring is automatically shown by beams of light and mirrors and the horse-power is read off a scale. At 9,000 revolutions per minute, with 125 pounds at the throttle and free exhaust, this turbine develops 200 horse-power. It weighs two pounds per horse-power.

The Tesla turbine testing plant at the Edison Waterside Station, New York.

The Tesla Steam Turbine

The Rotary Heat Motor Reduced to Its Simplest Terms

and free exhaust, this turbine develop...

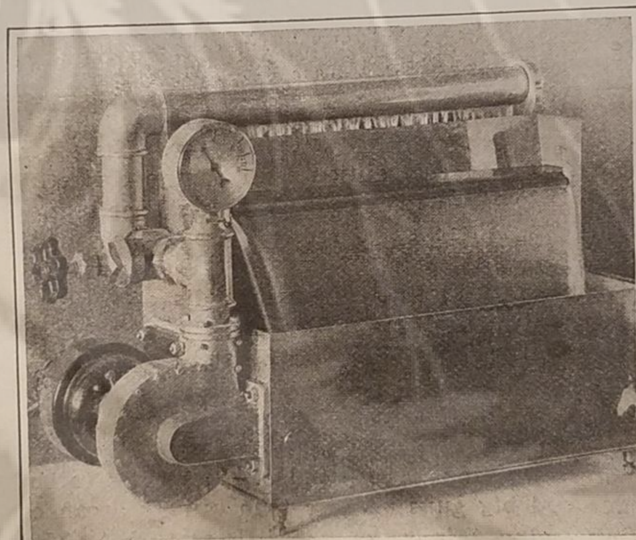
The Tesla turbine testing plant at the Edison Waterside Station, New York.

The Tesla Steam Turbine

The Rotary Heat Motor Reduced to Its Simplest Terms

he SCIENTIFIC AMERI-
a, whose reputation
ntributions he made
e art was yet in its
ng and choice a me-
aning to that branch
rm "steam engineer-
has devoted much of
thermo-dynamic con-
heories and practical
n entirely new form
tion at the Waterside
Company, who kindly
plant at his disposal
k.
or, we are enabled to
ws, representing the
tation, which are the
ting motor that have

ermined Tesla's inves-
ct that when a fluid



This little pump, driven by a motor of $\frac{1}{12}$ horse-power, is here shown delivering 40 gallons of water per minute against a 9-foot head.

The turbine used as a pump.

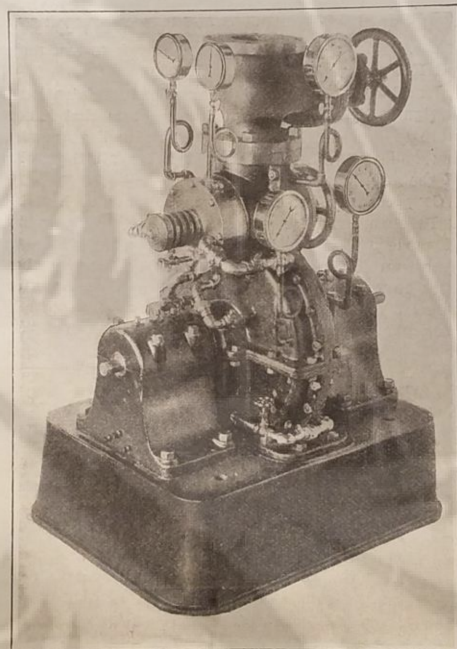
output of 200 hors
turbine with atmos
2 pounds per horse
a space measuring
and which accompl
fall of only 130 B.T
total drop availabl
the mechanical star
simple and econon
very nature of its
sess such a durab
breakdown as to
advance of any ty
present day.

Briefly stated, T
of flat steel disks
within a casing, th
at the periphery o
free spiral paths, a
ports at their cent
of the steam by
series of blades or

of their great plant at his disposal
rimental work.
f the inventor, we are enabled to
panying views, representing the
Waterside station, which are the
this interesting motor that have
c.
e which determined Tesla's inves-
ell-known fact that when a fluid
r) is used as a vehicle of energy,
e economy can be obtained only
in velocity and direction of the
uid are made as gradual and easy
present forms of turbines in which
smitted by pressure, reaction or
De Laval, Parsons, and Curtiss
sudden changes both of speed and
ed, with consequent shocks, vibra-
e eddies. Furthermore, the intro-
blades, buckets, and intercepting
eral class, into the path of the
delicate and difficult mechanical
adds greatly to the cost both of
ntenance.
an ideal turbine group themselves
he theoretical and the mechanical.
erfect turbine would be one in
so controlled from the inlet to the
ergy was delivered to the driving
possible losses due to the mechan-
d. The mechanically perfect tur-
which combined simplicity and
ction, durability, ease and rapidity
nall ratio of weight and space oc-
delivered on the shaft. Mr. Tesla
e turbine which forms the subject
s carried the steam and gas motor
toward the maximum attainable
etical and mechanical. That these
nded is shown by the fact that in
dison station, he is securing an

This little pump, driven by a motor of $\frac{1}{12}$ horse-power, is here shown delivering 40 gallons of water per minute against a 9-foot head.

The turbine used as a pump.



This view shows one complete high pressure unit, with the steam throttle above, and below it the reversing valve and the compact turbine. Note the many gages used in the tests.

A 200-horse-power high-pressure turbine.

Briefly stated, Tesla's steam motor consist
of flat steel disks mounted on a shaft an
within a casing, the steam entering with hig
at the periphery of the disks, flowing betwee
free spiral paths, and finally escaping throug
ports at their center. Instead of developing
of the steam by pressure, reaction, or im
series of blades or vanes, Tesla depends upo
properties of adhesion and viscosity—the at
the steam to the faces of the disks and the
of its particles to molecular separation com
transmitting the velocity energy of the moti
the plates and the shaft.

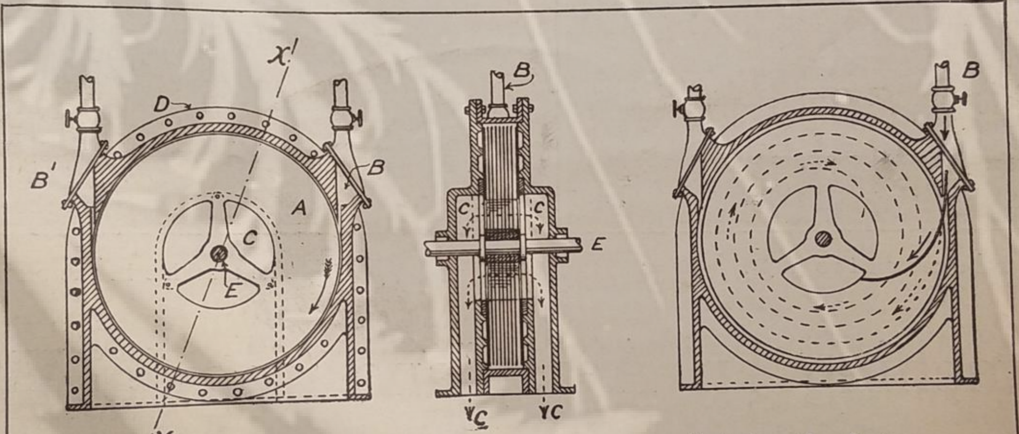
By reference to the accompanying photog
line drawings, it will be seen that the turb
rotor *A* which in the present case consists
steel disks, one thirty-second of an inch in
of hardened and carefully tempered steel.
as assembled is 3½ inches wide on the fa
inches in diameter, and when the turbine i
at its maximum working velocity, the m
never under a tensile stress exceeding 50,0
per square inch. The rotor is mounted in
D, which is provided with two inlet n
for use in running direct and *B′* for reversi
ings *C* are cut out at the central portion of
and these communicate directly with exha
formed in the side of the casing.

In operation, the steam, or gas, as the cas
is directed on the periphery of the disks th
nozzle *B* (which may be diverging, straig
verging), where more or less of its expansi
is converted into velocity energy. When the
is at rest, the radial and tangential forces d
pressure and velocity of the steam cause it to
a rather short curved path toward the centr
opening, as indicated by the full black li
accompanying diagram; but as the disks com
rotate and their speed increases, the steam
spiral paths the length of which increases

ve speed, which is at
of the disks and is
of the steam. Hence
is very great, being
entrifugal force acting
desir-
urbine
we are
nd fre-
which
e this
turbine
ersing,
red by
valve

ples of
licable,
gn, for
esent a
model
Tesla's
ven by
-power,
against
ge pipe
provided with a wire
nd checking the eddies.
slot in the bottom of
ow a baffle plate flows

mal efficiencies have been obtained which demonstrate that in large machines based on this principle, in which a very small slip can be secured, the steam consumption will be much lower and should, Mr. Tesla states, approximate the theoretical minimum, thus resulting in nearly frictionless tur-



Sectional views. Spiral path of steam.

Details of turbine.

bine transmitting almost the entire expansive energy of the steam to the shaft.

Some Striking Coal Facts

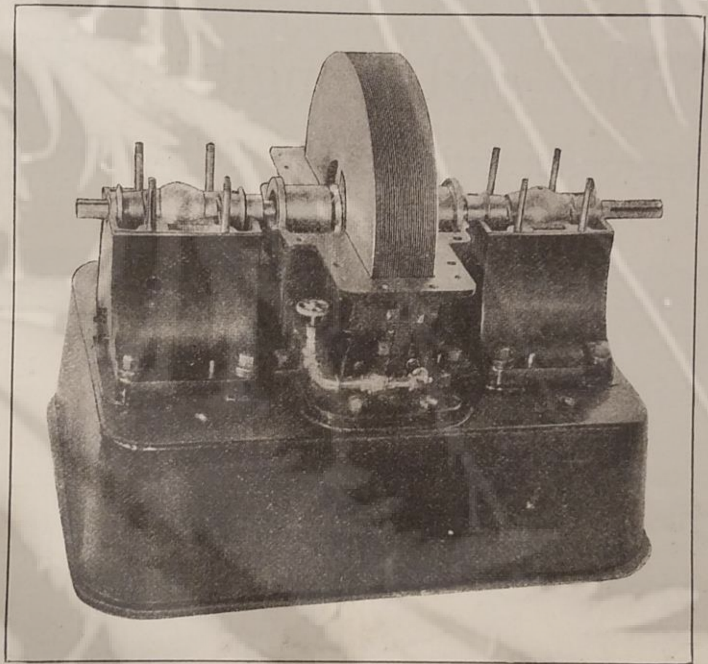
in 1900 it was 3½ to
tion of 91,972,266 the
for each person.

Last year 725,030
States. The great co
made in spite of a s
in
wage
$30,0
Th
mak
for
187,
by-p
man
Th
Unit
was
plus
min
13,3
Sta
the
gro
clus
ton
exh
an apparent supply
tons, or 99.6 per ce
words, in all the ti
United States the
cluding loss in m

noted that although the
aterside station develops
unds at the supply
ld show an output
e full pressure of
Furthermore, Mr.
e compounded and
low pressure unit,
ne number of disks
ure element, with
fording 28½ to 29
ts obtained in the
e indicate that the
an output of 600
ncrease of dimen-
ervative.

of two identical
refully calibrated
to the left being
er the brake. In
n is delivered to
pposite to that of
Fastened to the
s a hollow pulley
ally opposite nar-
t lamp placed in-
he pulley rotates,
of the same, and
s and lenses, they
and fall upon two
back to back on
bine so that the
gs coincides with
mirrors are so set that

The mere increase of the coal output of the United States for 1910 over that of 1909—40,781,762 tons—was greater than the total production of any foreign



This turbine, whose rotor consists simply of a set of flat disks 18 inches in diameter, develops 200 brake horse-power on test.

Turbine with upper half of casing removed.

country except Great Britain, Germany, Austria, Hun-

Foreign Students

ADDRESSING the House o
many new activities of the
service, Representative
chairman of the House
mittee, recently called
made by our diplomat
sentatives to advertise t
educational center, an
been fruitful of results.

One of the outcomes
the formation in Bueno
of a United States Univ
been the means of send
Argentinians to this co
Under the auspices of
given on university life
illustrated with a large
stereopticon views. Nego
way for an interchange
the Boston High School
preparatory department
La Plata. There are n
Americans studying in
the number is steadily

Through the efforts
Constantinople, supported
ment, Columbia Univers
ceive, free of all tuition
annually from the Otto
next ten years, to pursu
any of the departmen
These students are to b
man government, with t
of the ambassador at Constan

SCIENTIFIC AMERICAN

(Entered at the Post Office of New York, N. Y., as Second Class Matter. Copyright, 1904, by Munn & Co.)

Vol. XC.—No. 23.
ESTABLISHED 1845.

NEW YORK, JUNE 4, 1904

8 CENTS A COPY
\$3.00 A YEAR.

Torpedo Gunboat "Miyako."
1,800 tons, 20 knots.
Sunk by mine.

Protected Cruiser "Yoshino."
4 150 tons, 23.08 knots.
Rammed and sunk.

Torpedo Boat No. 48.
135 tons, 27 knots.
Sunk by mine.

Torpedo-Boat Destroyer "Akatsuki."
388 tons, 31 knots.
Destroyed by shell.

Displacement, 15,000 tons. **Speed,** 19.1 knots. **Complement,** 741.

Battleship "Hatsuse," Sunk by a Mine, With Loss of 450 Men.

THE JAPANESE NAVAL DISASTERS.—[See page 438.]

SCIENTIFIC AMERICAN SUPPLEMENT. No. 1483

Entered at the Post Office of New York, N. Y., as Second Class Matter. Copyright, 1904, by Munn & Co.

Scientific American, established 1845
Scientific American Supplement, Vol. LVII., No. 1483.

NEW YORK, JUNE 4, 1904.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

THE ELIZABETH BRIDGE, BUDA-PEST.

A SUSPENSION bridge presenting various novel engineering features has been opened at Budapest. We propose to illustrate and describe this bridge. But in the first place, it is well to explain how it came to be erected. We are indebted to Mr. Charles Peter Dubez, engineer to the Buda-Pest Electric Railway Company, for the following historical sketch.

The necessity for erecting and opening the Elizabeth Bridge was like the necessity for erecting and opening the famous Suspension Bridge, Margaret Bridge, Railway-Connecting Bridge, New Pest Bridge, and Francis Joseph Bridge, due to the very rapid development of the capital, Buda-Pest. Before the erection of the first permanent bridge, Buda-Pest was not yet called by the present name, "Buda-Pest"; there was a separate town called "Buda" on the right-hand side of the river Danube, and a separate town "Pest," on the left. The traffic between the two towns, however, soon required a roadway leading from one town into the other. Thus a pontoon bridge was made. However, the trade and commerce between the two towns soon led the City Board of Trade to the conviction that so primitive a bridge was quite unfit for carrying and conveying the constantly increasing traffic. The Board of Trade therefore urged the government to have built a permanent bridge of more suitable dimensions and construction.

Thus it was decided to erect the very first permanent bridge over the waterway, and for this purpose Mr. William Clark's designs were accepted, and he was at the same time also intrusted with carrying out the work. The bridge itself was to be called after its type "Lánczhid." However, Mr. William Clark died while the bridge was being made, and so his brother, Mr. Adam Clark, was appointed to take his place, and put in absolute charge of the construction. Mr. Adam Clark succeeded in completing the work, so that the bridge was ready to be opened on November 20, 1849.

In those days, when the Hungarian art of bridge-building was not on its present level, Budapest had to look and search very far abroad for experts, engineers, and even workmen, as also for the necessary ironwork, castings, fittings, and materials, that were required for building and completing bridges. Mr. Dubez's late grandfather, Mr. C. Frommhold, who was the leading physician, as also the only English-speaking gentleman at that time in Pest, and who was also appointed doctor of the whole English bridge-building colony, could not speak highly enough of the superior quality of the English working class.

So the "Lánczhid" was erected between 1840 and 1849, and is still nowadays quite unequaled—it is unique of its kind, decorating this delightful city. The length of its main span is 664.41 feet, while the two land approaches have a length of 286.6 feet each, thus giving the entire suspension bridge a total length of fully 1,233.65 feet between the two abutments.

This bridge on the one hand is a fine example of English art and bridge building, and on the other hand permanently remains as an ideal bridge for closely connecting together the friendliest feelings of the two great nations.

The rapid growth of population, however, soon led the government to the conviction that this "Lánczhid" would not prove sufficient in regard to traffic in the very next decades. The government was not mistaken in this supposition in the least, as about twenty-five years later it proved to be urgently necessary to erect a second permanent bridge over the river Danube, between Buda and Pest. It was the "Margit hid" (Margaret Bridge) that was made, which has a total length of 1,884.73 feet, including the two land approaches 72.18 feet long each. This bridge was opened on April 30, 1876.

However, the further rapid growth and development of Budapest rendered necessary in the next twenty-seven years not fewer than four more bridges. They were the "Osszeltötö vasuti hid" (railway connecting bridge), the "Ujpesti hid" (New Pest Bridge), the "Ferencz József hid" (Francis Joseph Bridge), and the "Erzsébet hid" (Elizabeth Bridge).

Judging from the present development of this city, it is safe to say that in the course of about ten to twenty years, two more bridges are likely to be erected over the river Danube at Budapest; the one will be the "O'Budai hid" (Old Buda Bridge), the other the "Borárostéri hid" (Boráros-Square Bridge).

It was on October 10, 1903, at 11 A. M., that the Elizabeth Bridge was opened. Although it is now the sixth permanent bridge over the river Danube in the territory of Budapest, still it comes first, not merely at Budapest, but also in Hungary, as to its huge structure and in respect of the length of its main span. It is unquestionably a grand work of modern engineering, evidencing the uninterrupted increase of traffic and population. The opening of the bridge was performed in the presence of Archduke Joseph, who represented his Majesty, Francis Joseph, the King of Hungary. By consent of his Majesty the bridge is called "Elizabeth Bridge" in commemoration of the late Queen Elizabeth.

The actual history of the Elizabeth Bridge dates back to as early as 1893, when the Board of Trade, seeing that the bridges already in use at Budapest were not able to fulfill the traffic requirements properly, urged the government to have two more bridges erected. One of them was the Francis Joseph Bridge, erected according to the designs of Mr. John Feketcházy, at that time chief engineer to the Hungarian Royal State Railways, and thrown open to traffic on the 4th of October, 1896; the other one the Elizabeth Bridge. The principal difference between the Elizabeth Bridge and the others is that the Elizabeth Bridge has only one span over the river Danube, and two piers, one on each side of the river, built on substantial ground. Its clear span over the river Danube is 951½ feet. There are two land approaches, one on each side of the river, each having a length of 40 meters, thus giving the entire bridge a total length of fully 3,014 feet. The two piers, one on each side of the river Danube, have a total height of 212 feet each over the zero level of the water. Both of them are made of steel and rest upon granite foundations. The highest point at the center of the bridge is 59 feet from the zero level of the river Danube. The principal constituent parts of the whole bridge are such that the two lattice-typed main girders have the four chains, two on each side. The dip or versed sine of the chain curve is 95 feet, thus being one-tenth of the length of the main span. Therefore the chains are supported by the piers at a height of 95 feet from their lowest points, and are anchored down into the masonry of the abutments. The chains themselves carry by means of suspension rods the cross-girders of

THE ELIZABETH SUSPENSION BRIDGE AT BUDA-PEST.

were "flitted" from end to end. An important desideratum was the shortening to as fine a point as possible of the wagoning of the coal from the face to the haulage rope. In conclusion, he might safely claim that they had attained such definite objects as: (1) More output per man employed; (2) coal economically worked which previously had been unworkable to a profit by hand; (3) more systematic working; (4) better round coal in three out of four mines; (5) greater area exposed in same time in two out of four seams; (6) premium per ton for risk of life reduced by one-third. It was scarcely possible to say how far the effect of coal-cutting reached. [illegible] to keep better vigilance than before, not only as regards safety, but also to keep the machine "forging ahead," as the next day's output depended largely upon it. The collier had been disturbed in his nest at the face. He now met the mechanic and the electrician on his own private preserve, and no doubt considered them interlopers; work of a higher class, such as the mechanical and electrical, was displacing, say, 33 per cent of the colliers' work, and that the most laborious. Therefore, having installed the coal-cutters, the Hulton Colliery would certainly consider that a return to the hand labor would be a step back into the older and darker times.

FIG. 1.—TESLA EXPERIMENTAL LABORATORY IN COLORADO, ERECTED DURING THE SUMMER OF 1899.

(The discovery by Mr. Tesla of the stationary waves in the earth was made here.)

THE TRANSMISSION OF ELECTRIC ENERGY WITHOUT WIRES.*

By NIKOLA TESLA.

TOWARD the close of 1898 a systematic research, carried on for a number of years with the object of perfecting a method of transmission of electrical energy through the natural medium, led me to recognize three important necessities: First, to develop a transmitter of great power; second, to perfect means for individualizing and isolating the energy transmitted; and, third, to ascertain the laws of propagation of currents through the earth and the atmosphere. Various reasons, not the least of which was the help proffered by my friend Leonard E. Curtis and the Colorado Springs Electric Company, determined me to select for my experimental investigations the large plateau, two thousand meters above sea level, in the vicinity of that delightful resort, which I reached late in May, 1899. I had been there but a few days when I congratulated myself on the happy choice, and I began the task for which I had long trained myself, with a grateful sense and full of inspiring hope. The perfect purity of the air, the unequaled beauty of the sky, the imposing sight of a high mountain range, the quiet and restfulness of the place—all around contributed to make the conditions for scientific observation ideal. To this was added the exhilarating influence of a glorious climate and a singular sharpening of the senses. In those regions the organs undergo perceptible physical changes. The eyes assume an extraordinary limpidity, improving vision; the ears dry out and become more susceptible to sound. Objects can be clearly distinguished there at distances such that I prefer to have them told by someone else, and I have heard—this I can venture to vouch for—the claps of thunder seven and eight hundred kilometers away. I might have done better still, had it not been tedious to wait for the sounds to arrive, in definite intervals, as heralded precisely by an electrical indicating apparatus—nearly an hour before.

In the middle of June, while preparations for other work were going on, I arranged one of my receiving transformers with the view of determining in a novel manner, experimentally, the electric potential of the globe and studying its periodic and casual fluctuations. This formed part of a plan carefully mapped out in advance. A highly sensitive, self-restorative device, controlling a recording instrument, was included in the secondary circuit, while the primary was connected to the ground and an elevated terminal of adjustable capacity. The variations of potential gave rise to electric surgings in the primary; these generated secondary currents, which in turn affected the sensitive device and recorder in proportion to their intensity. The earth was found to be, literally, alive with electrical vibrations, and soon I was deeply absorbed in this interesting investigation. No better opportunities for such observations as I intended to make could be found anywhere. Colorado is a country famous for the natural displays of electric force. In that dry and rarefied atmosphere the sun's rays beat the objects with fierce intensity. I raised steam, to a dangerous pressure, in barrels filled with concentrated salt solution, and the tinfoil coatings of some of my elevated terminals shriveled up in the fiery blaze. An experimental high-tension transformer, carelessly exposed to the rays of the setting sun, had most of its insulating compound melted out and was rendered useless. Aided by the dryness and rarefaction of the air, the water evaporates as in a boiler, and static electricity is developed in abundance. Lightning discharges are, accordingly, very frequent and sometimes of inconceivable violence. On one occasion approximately twelve thousand discharges occurred in two hours, and all in a radius of certainly less than fifty kilometers from the laboratory. Many of them resembled gigantic trees of fire with the trunks up or down. I never saw fire balls, but as a compensation for my disappointment I succeeded later in determining the mode of their formation and producing them artificially.

In the latter part of the same month I noticed several times that my instruments were affected stronger by discharges taking place at great distances than by those near by. This puzzled me very much. What was the cause? A number of observations proved that it could not be due to the differences in the intensity of the individual discharges, and I readily ascertained that the phenomenon was not the result of a varying relation between the periods of my receiving circuits and those of the terrestrial disturbances. One night, as I was walking home with my assistant, meditating over these experiences, I was suddenly staggered by a thought. Years ago, when I wrote a chapter of my lecture before the Franklin Institute and the National Electric Light Association, it had presented itself to me, but I had dismissed it as absurd and impossible. I banished it again. Nevertheless, my instinct was aroused and somehow I felt that I was nearing a great revelation.

It was on the third of July—the date I shall never forget—when I obtained the first decisive experimental evidence of a truth of overwhelming importance for the advancement of humanity. A dense mass of strongly charged clouds gathered in the west and toward the evening a violent storm broke loose which, after spending much of its fury in the mountains, was driven away with great velocity over the plains. Heavy and long persisting arcs formed almost in regular time intervals. My observations were now greatly facilitated and rendered more accurate by the experiences already gained. I was able to handle my instruments quickly and I was prepared. The recording apparatus being properly adjusted, its indications became fainter and fainter with the increasing distance of the storm, until they ceased altogether. I was watching in eager expectation. Surely enough, in a little while the indications again began, grew stronger and stronger and, after passing through a maximum, gradually decreased and ceased once more. Many times, in regularly recurring intervals, the same actions were repeated, until the storm which, as evident from simple computations, was moving with nearly constant speed, had retreated to a distance of about three hundred kilometers (186 miles). Nor did these strange actions stop then, but continued to manifest themselves with undiminished force. Subsequently, similar observations were also made by my assistant, Mr. Fritz Lowenstein, and shortly afterward several admirable opportunities presented themselves which brought out, still more forcibly, and unmistakably, the true nature of the wonderful phenomenon. No doubt whatever remained—I was observing stationary waves.

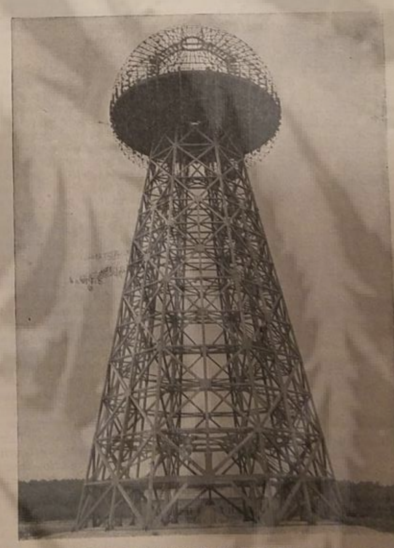


FIG. 2.—TESLA CENTRAL POWER PLANT AND TRANSMITTING TOWER FOR WORLD TELEGRAPHY, AT WARDENCLYFFE, LONG ISLAND, N. Y.

(The tower is a pyramid having eight sides; smallest dimensions across base, 95 feet; height, 154 feet; total height from ground to top, 187 feet; cupola on top, 65.62 feet in diameter.)

* Electrical World and Engineer.

As the source of disturbance moved away, the receiving circuit came successively upon their nodes and loops. Impossible as it seemed, this planet, despite its vast extent, behaved like a conductor of limited dimensions. The tremendous significance of this fact in the transmission of energy by my system had already become quite clear to me. Not only was it practicable to send telegraphic messages to any distance without wires, as I recognized long ago, but also to impress upon the entire globe the faint modulations of the human voice, far more still, to transmit power, in unlimited amounts, to any terrestrial distance and almost without any loss.

With these stupendous possibilities in sight, with the experimental evidence before me that their realization was henceforth merely a question of expert knowledge, patience, and skill, I attacked vigorously the development of my magnifying transmitter, now, however, not so much with the original intention of producing one of great power as with the object of learning how to construct the best one. This is, essentially, a circuit of very high self-induction and small resistance which, in its arrangement, mode of excitation, and action, may be said to be the diametrically opposite of a transmitting circuit typical of telegraphy by Hertzian or electromagnetic radiations. It is difficult to form an adequate idea of the marvelous power of this unique appliance, by the aid of which the globe will be transformed. The electromagnetic radiations being reduced to an insignificant quantity, and proper conditions of resonance maintained, the circuit acts like an immense pendulum, storing indefinitely the energy of the primary exciting impulses and impressing upon the earth and its conducting atmosphere uniform harmonic oscillations of intensities which, as actual tests have shown, may be pushed so far as to surpass those attained in the natural displays of static electricity.

Simultaneously with these endeavors, the means of individualization and isolation were gradually improved. Great importance was attached to this, for it was found that simple tuning was not sufficient to meet the vigorous practical requirements. The fundamental idea of employing a number of distinctive elements, co-operatively associated, for the purpose of isolating energy transmitted, I trace directly to my perusal of Spencer's clear and suggestive exposition of the human nerve mechanism. The influence of this principle on the transmission of intelligence, and electrical energy in general, cannot as yet be estimated, for the art is still in the embryonic stage; but many thousands of simultaneous telegraphic and telephonic messages, through one single conducting channel, natural or artificial, and without serious mutual interference, are certainly practicable, while millions are possible. On the other hand, any desired degree of individualization may be secured by the use of a great number of co-operative elements and arbitrary variation of their distinctive features and order of succession. For obvious reasons, the principle will also be valuable in the extension of the distance of transmission.

Progress, though of necessity slow, was steady and sure, for the objects aimed at were in a direction of my constant study and exercise. It is, therefore, not astonishing that before the end of 1899 I completed the task undertaken and reached the results which I have announced in my article in the Century Magazine of June, 1900, every word of which was carefully weighed.

Much has already been done toward making my system commercially available, in the transmission of energy in small amounts for specific purposes, as well as on an industrial scale. The results attained by me have made my scheme of intelligence transmission, for which the name of "world telegraphy" has been suggested, easily realizable. It constitutes, I believe, in its principle of operation, means employed, and capacities of application, a radical and fruitful departure from what has been done heretofore. I have no doubt that it will prove very efficient in enlightening the masses, particularly in still uncivilized countries and less accessible regions, and that it will add materially to general safety, comfort, and convenience, and maintenance of peaceful relations. It involves the employment of a number of plants, all of which are capable of transmitting individualized signals to the uttermost confines of the earth. Each of them will be preferably located near some important center of civilization and the news it receives through any channel will be flashed to all points of the globe. A cheap and simple device, which might be carried in one's pocket, may then be set up somewhere on sea or land, and it will record the world's news or such special messages as may be intended for it. Thus the entire earth will be converted into a huge brain, as it were, capable of response in every one of its parts. Since a single plant of but one hundred horse-power can operate hundreds of millions of instruments, the system will have a virtually infinite working capacity, and it must needs immensely facilitate and cheapen the transmission of intelligence.

The first of these central plants would have been already completed had it not been for unforeseen delays which, fortunately, have nothing to do with its purely technical features. But this loss of time, while vexatious, may after all prove to be a blessing in disguise. The best design of which I knew has been adopted, and the transmitter will emit a wave complex of a total maximum activity of ten million horse-power, one per cent of which is amply sufficient to "girdle the globe." This enormous rate of energy delivery, approximately twice that of the combined falls of Niagara, is obtainable only by the use of certain artifices, which I shall make known in due course.

For a large part of the work which I have done so far I am indebted to the noble generosity of Mr. J. P. Morgan, which was all the more welcome and stimulating, as it was extended at a time when those who have since promised most were the greatest of doubters. I have also to thank my friend, Stanford White, for much unselfish and valuable assistance. This work is now far advanced, and though the results may be tardy, they are sure to come.

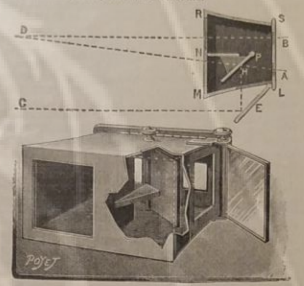


FIG. 1.—BELLIENI'S APEDIOSCOPE FOR OBSERVING STEREOSCOPIC PROJECTIONS.

Meanwhile, the transmission of energy on an industrial scale is not being neglected. The Canadian Niagara Power Company have offered me a splendid inducement, and next to achieving success for the sake of the art, it will give me the greatest satisfaction to make their concession financially profitable to them. In this first power plant, which I have been designing for a long time, I propose to distribute ten thousand horse-power under a tension of one hundred million volts, which I am now able to produce and handle with safety.

The energy will be collected all over the globe, preferably in small amounts, ranging from a fraction of one to a few horse-power. One of its chief uses will be the illumination of isolated homes. It takes very little power to light a dwelling with vacuum tubes operated by high-frequency currents, and in each instance a terminal a little above the roof will be sufficient. Another valuable application will be the driving of clocks and other such apparatus. These clocks will be exceedingly simple, will require absolutely no

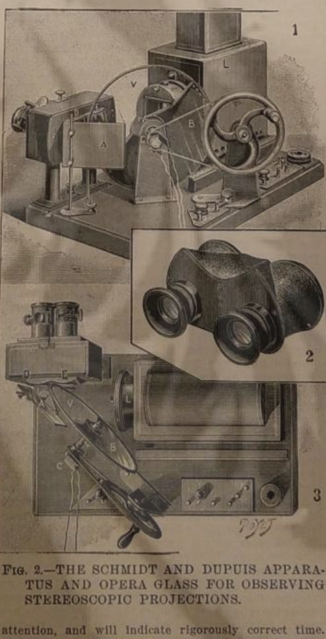


FIG. 2.—THE SCHMIDT AND DUPUIS APPARATUS AND OPERA GLASS FOR OBSERVING STEREOSCOPIC PROJECTIONS.

attention, and will indicate rigorously correct time. The idea of impressing upon the earth American time is fascinating and very likely to become popular. There are innumerable devices of all kinds which are either now employed or can be supplied, and by operating them in this manner I may be able to offer a great convenience to the whole world with a plant of no more than ten thousand horse-power. The introduction of this system will give opportunities for invention and manufacture such as have never presented themselves before.

Knowing the far-reaching importance of this first attempt and its effect upon future development, I shall proceed slowly and carefully. Experience has taught me not to assign a term to enterprises the consummation of which is not wholly dependent on my own abilities and exertions. But I am hopeful that these great realizations are not far off, and I know that when this first work is completed they will follow with mathematical certitude.

When the great truth accidentally revealed and experimentally confirmed is fully recognized, that this planet, with all its appalling immensity, is to electric currents virtually no more than a small metal ball, and that by virtue of this fact many possibilities, each baffling imagination and of incalculable consequence, are rendered absolutely sure of accomplishment; when the first plant is inaugurated and it is shown that a telegraphic message, almost as secret and non-interferable as a thought, can be transmitted to any terrestrial distance, the sound of the human voice, with all its intonations and inflections faithfully and instantly reproduced at any other point of the globe, the energy of a waterfall made available for supplying light, heat or motive power, anywhere—on sea, or land, or high in the air—humanity will be like an antheap stirred up with a stick. See the excitement coming!

STEREOSCOPIC PROJECTIONS.

In order that images may be seen in relief by stereoscopic projections, it does not suffice to project upon the screen the two images emanating from a stereoscopic negative, but it is also necessary that it shall be possible for each eye of the spectator, through an appropriate arrangement, to receive only that one of the two images that is designed for it. There exists a stereoscope for images of large dimensions, and that is the mirror apparatus of M. Cazes; but this is not easily manipulated and cannot be employed by the spectators at an ordinary exhibition of stereoscopic lantern slides. Other inventors, and M. Knight especially, have indicated the possibility of constructing portable apparatus on the same principle. We do not know whether or not the idea was ever carried out, but it appears, at all events, to have fallen into oblivion. Quite recently, M. Bellieni, taking up the same idea, and without knowing anything at all about the work of M. Knight, has succeeded in constructing the apedioscope, a small and easily portable apparatus of moderate price, with which each spectator may provide himself when a lecture, for example, is illustrated with stereoscopic projections. Experimented with recently at a meeting of the French Photographic Society, in which the inventor placed thirty of these apparatus at the disposal of the members, it gave excellent results.

Use is made of the stereoscopic positive upon glass, such as is found in the collections for the ordinary stereoscope (care being taken to remove the ground glass if any exists). This is passed into a single-objective lantern. A 6-inch condenser suffices for $3\frac{1}{4} \times 6\frac{1}{2}$-inch slides, and a $4\frac{3}{4}$-inch one for $2\frac{1}{4} \times 5$-inch slides.

The two images are thus projected upon the screen, one alongside of the other. In order to answer the requirements of the principle mentioned above, the spectator's apparatus consists of a small box, *M R S L*, containing two apertures, *A* and *B*, situated at the normal distance apart of the eyes (Fig. 1). Through one of these, *B*, we see directly with the right eye, for instance, one of the two images, *D*, which is the one intended for that eye. The other image, *C*, is concealed from the right eye by a wooden partition, *N P*, placed in the apparatus. But this other image is reflected in a small mirror, *E*, situated upon the other side of the box, and capable of being set in the proper position by means of a button. After the image, *C*, is properly perfected by this mirror, it is received by a second mirror, *H*, placed in the interior of the apparatus. It is here that the right eye, placed at *A*, sees it appear, and instinctively transfers it to *D*, beyond the mirror superposing it upon the first image. This gives the effect of reliefs, as in the ordinary stereoscope.

The slight regulation necessary for the proper reception of one of the images in the mirror is done once for all at the beginning of the lecture or other entertainment by means of a geometrical figure, for example, of which only a part need be projected on each side, but of which the superposition must be made to appear complete. It is to be remarked that this system occasions no loss of light.

There are still other methods of viewing stereoscopic lantern slides in relief. This question was discussed by us thirteen years ago, when M. Molteni projected the two images one upon the other, after having colored one of them red and the other green, by means of colored glasses placed before them. The spectators had to be provided with eye-glasses having the same colors. It is evident that, under such circumstances, each eye can see only the image that is designed for it, and the relief is easily perceived. But these multicolored screens upon the lantern and the eyes absorb too great a quantity of light, and that is what has prevented the development of this system of stereoscopic projection.

The idea has been taken up under another form by various persons, and, among others, by M. Rateau; and we have recently seen it carried out in a very complete manner by MM. Schmidt and Dupuis. The process consists in projecting the two images successively. If the spectator opens but one eye at a time—the left

nclusion, he might safely claim that d such definite objects as: (1) More employed; (2) coal economically work-

controlling a recording instrument, wa the secondary circuit, while the primary to the ground and an elevated terminal

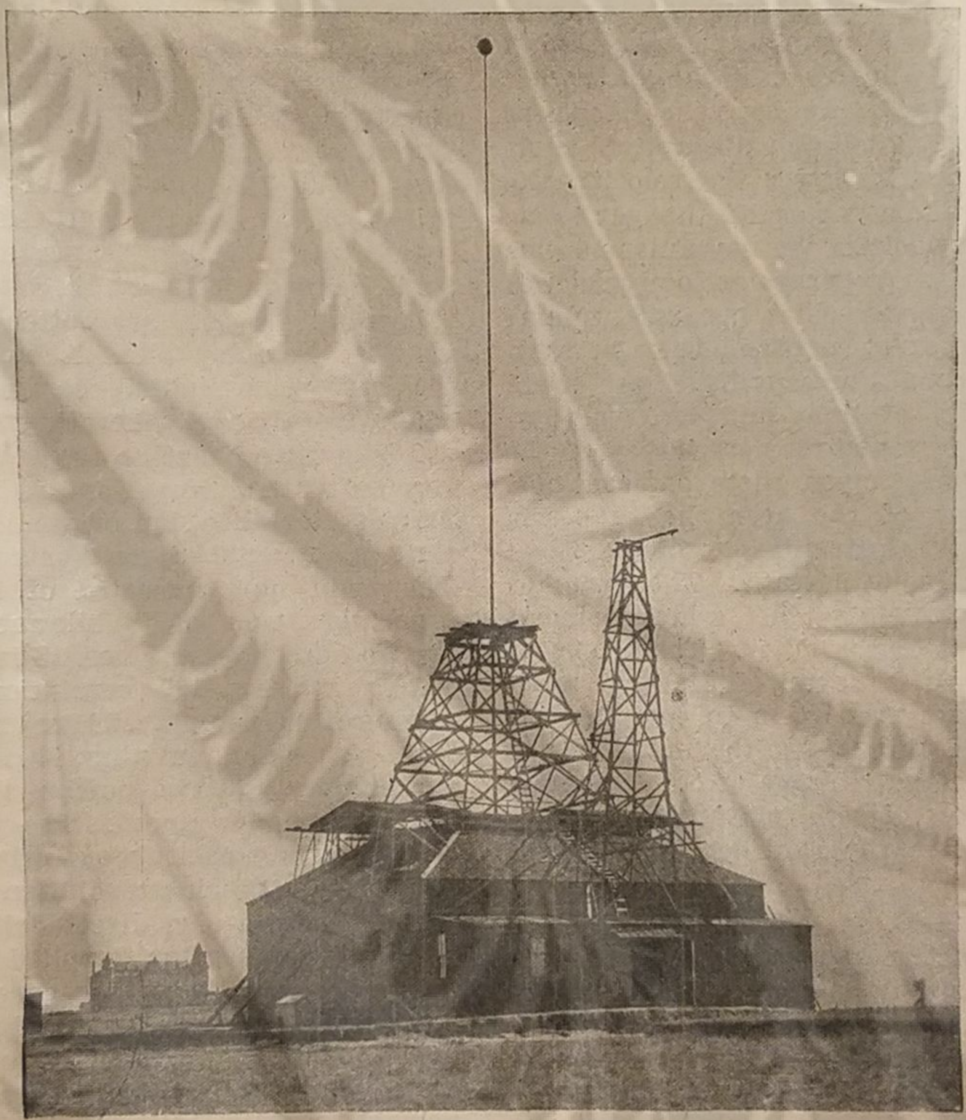


Fig. 1.—TESLA EXPERIMENTAL LABORATORY IN COLORADO, ERECTED DURING THE SUMMER OF 1899.

(The discovery by Mr. Tesla of the stationary waves in the earth was made here.)

ously had been unworkable to a profit more systematic working; (4) better three out of four mines; (5) greater same time in two out of four seams; er ton for risk of life reduced by one- carcely possible to say how far the ef-

capacity. The variations of potential electric surgings in the primary; th secondary currents, which in turn affec tive device and recorder in proportion t ity. The earth was found to be, literal electrical vibrations, and soon I was de

re. Colorado is a country famous for lays of electric force. In that dry osphere the sun's rays beat the objects

treated to a distance of about three ters (186 miles). Nor did these strange ac then, but continued to manifest themselves

Fig. 2.—TESLA CENTRAL POWER PLANT AND TRANSMITTING TOWER FOR WORLD TELEGRAPHY, AT WARDENCLYFFE, LONG ISLAND, N. Y.

(The tower is a pyramid having eight sides; smallest dimensions across base, 95 feet; height, 154 feet; total height from ground to top, 187 feet; cupola on top, 65.62 feet in diameter.)

were "flitted" from end to end. An important desideratum was the shortening to as fine a point as possible of the wagoning of the coal from the face to the haulage rope. In conclusion, he might safely claim that they had attained such definite objects as: (1) More output per man employed; (2) coal economically worked which previously had been unworkable to a profit by hand; (3) more systematic working; (4) better round coal in three out of four mines; (5) greater area exposed in same time in two out of four seams; (6) premium per ton for risk of life reduced by one-third. It was scarcely possible to say how far the effect of coal-cutting reached. T... to keep better vigilance than before, not only as regards safety, but also to keep the machine "forging ahead," as the next day's output depended largely upon it. The collier had been disturbed in his nest at the face. He now met the mechanic and the electrician on his own private preserve, and no doubt considered them interlopers; work of a higher class, such as the mechanical and electrical, was displacing, say, 33 per cent of the colliers' work, and that the most laborious. Therefore, having installed the coal-cutters, the Hulton Colliery would certainly consider that a return to the hand labor would be a step back into the older and darker times.

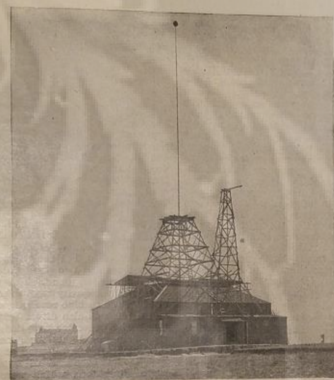


FIG. 1.—TESLA EXPERIMENTAL LABORATORY IN COLORADO, ERECTED DURING THE SUMMER OF 1899.

(The discovery by Mr. Tesla of the stationary waves in the earth was made here.)

THE TRANSMISSION OF ELECTRIC ENERGY WITHOUT WIRES.*

By NIKOLA TESLA.

TOWARD the close of 1898 a systematic research, carried on for a number of years with the object of per-

globe and studying its periodic and casual fluctuations. This formed part of a plan carefully mapped out in advance. A highly sensitive, self-restorative device, controlling a recording instrument, was included in the secondary circuit, while the primary was connected to the ground and an elevated terminal of adjustable capacity. The variations of potential gave rise to electric surgings in the primary; these generated secondary currents, which in turn affected the sensitive device and recorder in proportion to their intensity. The earth was found to be, literally, alive with electrical vibrations, and soon I was deeply absorbed in this interesting investigation. No better opportunities for such observations as I intended to make could be found anywhere. Colorado is a country famous for the natural displays of electric force. In that dry and rarefied atmosphere the sun's rays beat the objects by the dryness and rarefaction of the air, the water evaporates as in a boiler, and static electricity is developed in abundance. Lightning discharges are, accordingly, very frequent and sometimes of inconceivable violence. On one occasion approximately twelve thousand discharges occurred in two hours, and all in a radius of certainly less than fifty kilometers from the laboratory. Many of them resembled gigantic trees of fire with the trunks up or down. I never saw fire balls, but as a compensation for my disappointment I succeeded later in determining the mode of their formation and producing them artificially.

In the latter part of the same month I noticed several times that my instruments were affected stronger by discharges taking place at great distances than by those near by. This puzzled me very much. What was the cause? A number of observations proved that it could not be due to the differences in the intensity of the individual discharges, and I readily ascertained that the phenomenon was not the result of a varying relation between the periods of my receiving circuits and those of the terrestrial disturbances. One night, as I was walking home with my assistant, meditating over these experiences, I was suddenly staggered by a thought. Years ago, when I wrote a chapter of my lecture before the Franklin Institute and the National Electric Light Association, it had presented itself to me, but I had dismissed it as absurd and impossible. I banished it again. Nevertheless, my instinct was aroused and somehow I felt that I was nearing a great revelation.

It was on the third of July—the date I shall never forget—when I obtained the first decisive experimental evidence of a truth of overwhelming importance for the advancement of humanity. A dense mass of strongly charged clouds gathered in the west and toward the evening a violent storm broke loose which, after spending much of its fury in the mountains, was driven away with great velocity over the plains. Heavy and long persisting arcs formed almost in regular time intervals. My observations were now greatly facilitated and rendered more accurate by the experiences already gained. I was able to handle my instruments quickly and I was prepared. The recording apparatus being properly adjusted, its indications became fainter and fainter with the increasing distance of the storm, until they ceased altogether. I was watching in eager expectation. Surely enough, in a little while the indications again began, grew stronger and stronger and, after passing through a maximum, gradually decreased and ceased once more. Many times, in regularly recurring intervals, the same actions were repeated, until the storm which, as evident from simple computations, was moving with nearly constant speed, had retreated to a distance of about three hundred kilometers (186 miles). Nor did these strange actions stop then, but continued to manifest themselves with un-

better vigilance than before, not only as regards safety, but also to keep the machine "forging ahead," as the next day's output depended largely upon it. The collier had been disturbed in his nest at the face. He now met the mechanic and the electrician on his own private preserve, and no doubt considered them interlopers; work of a higher class, such as the mechanical and electrical, was displacing, say, 33 per cent of the colliers' work, and that the most laborious. Therefore, having installed the coal-cutters, the Hulton Colliery would certainly consider that a return to the hand labor would be a step back into the older and darker times.

THE TRANSMISSION OF ELECTRIC ENERGY WITHOUT WIRES.*

By Nikola Tesla.

Toward the close of 1898 a systematic research, carried on for a number of years with the object of perfecting a method of transmission of electrical energy through the natural medium, led me to recognize three important necessities: First, to develop a transmitter of great power; second, to perfect means for individualizing and isolating the energy transmitted; and, third, to ascertain the laws of propagation of currents through the earth and the atmosphere. Various reasons, not the least of which was the help proffered by my friend Leonard E. Curtis and the Colorado Springs Electric Company, determined me to select for my experimental investigations the large plateau, two thousand meters above sea level, in the vicinity of that delightful resort, which I reached late in May, 1899. I had been there but a few days when I congratulated myself on the happy choice, and I began the task for which I had long trained myself, with a grateful sense and full of inspiring hope. The perfect purity of the air, the unequaled beauty of the sky, the imposing sight of a high mountain range, the quiet and restfulness of the place—all around contributed to make the conditions for scientific observation ideal. To this was added the exhilarating influence of a glorious climate and a singular sharpening of the senses. In those regions the organs undergo perceptible physical changes. The eyes assume an extraordinary limpidity, improving vision; the ears dry out and become more susceptible to sound. Objects can be clearly distinguished there at distances such that I prefer to have them told by someone else, and I have heard—this I can venture to vouch for—the claps of thunder seven and eight hundred kilometers away. I might have done better still, had it not been tedious to wait for the sounds to arrive, in definite intervals, as heralded precisely by an electrical indicating apparatus—nearly an hour before.

In the middle of June, while preparations for other work were going on, I arranged one of my receiving transformers with the view of determining in a novel manner, experimentally, the electric potential of the

* Electrical World and Engineer.

... and soon I was deeply absorbed in this interesting investigation. No better opportunities for such observations as I intended to make could be found anywhere. Colorado is a country famous for the natural displays of electric force. In that dry and rarefied atmosphere the sun's rays beat the objects

... recurring intervals, the same actions were repeated, until the storm which, as evident from simple computations, was moving with nearly constant speed, had retreated to a distance of about three hundred kilometers (186 miles). Nor did these strange actions stop then, but continued to manifest themselves with un-

Fig. 2.—TESLA CENTRAL POWER PLANT AND TRANSMITTING TOWER FOR WORLD TELEGRAPHY, AT WARDENCLYFFE, LONG ISLAND, N. Y.

(The tower is a pyramid having eight sides; smallest dimensions across base, 95 feet; height, 154 feet; total height from ground to top, 187 feet; cupola on top, 65.62 feet in diameter.)

with fierce intensity. I raised steam, to a dangerous pressure, in barrels filled with concentrated salt solution, and the tinfoil coatings of some of my elevated terminals shriveled up in the fiery blaze. An experimental high-tension transformer, carelessly exposed to the rays of the setting sun, had most of its insulating compound melted out and was rendered useless. Aided

diminished force. Subsequently, similar observations were also made by my assistant, Mr. Fritz Lowenstein, and shortly afterward several admirable opportunities presented themselves which brought out, still more forcibly, and unmistakably, the true nature of the wonderful phenomenon. No doubt whatever remained—I was observing stationary waves.

As the source of disturbances moved away, the receiving circuit came successively upon their nodes and loops. Impossible as it seemed, this planet, despite its vast extent, behaved like a conductor of limited dimensions. The tremendous significance of this fact in the transmission of energy by my system had already become quite clear to me. Not only was it practicable to send telegraphic messages to any distance without wires, as I recognized long ago, but also to impress upon the entire globe the faint modulations of the human voice, far more still, to transmit power, in unlimited amounts, to any terrestrial distance and almost without any loss.

With these stupendous possibilities in sight, with the experimental evidence before me that their realization was henceforth merely a question of expert knowledge, patience, and skill, I attacked vigorously the development of my magnifying transmitter, now, however, not so much with the original intention of producing one of great power, as with the object of learning how to construct the best one. This is, essentially, a circuit of very high self-induction and small resistance which, in its arrangement, mode of excitation, and action, may be said to be the diametrically opposite of a transmitting circuit typical of telegraphy by Hertzian or electromagnetic radiations. It is difficult to form an adequate idea of the marvelous power of this unique appliance, by the aid of which the globe will be transformed. The electromagnetic radiations being reduced to an insignificant quantity, and proper conditions of resonance maintained, the circuit acts like an immense pendulum, storing indefinitely the energy of the primary exciting impulses and impressing upon the earth and its conducting atmosphere uniform harmonic oscillations of intensities which, as actual tests have shown, may be pushed so far as to surpass those attained in the natural displays of static electricity.

Simultaneously with these endeavors, the means of individualization and isolation were gradually improved. Great importance was attached to this, for it was found that simple tuning was not sufficient to meet the vigorous practical requirements. The fundamental idea of employing a number of distinctive elements, co-operatively associated, for the purpose of isolating energy transmitted, I trace directly to my perusal of Spencer's clear and suggestive exposition of the human nerve mechanism. The influence of this principle on the transmission of intelligence, and electrical energy in general, cannot as yet be estimated, for the art is still in the embryonic stage; but many thousands of simultaneous telegraphic and telephonic messages, through one single conducting channel, natural or artificial, and without serious mutual interference, are certainly practicable, while millions are possible. On the other hand, any desired degree of individualization may be secured by the use of a great number of co-operative elements and arbitrary variation of their distinctive features and order of succession. For obvious reasons, the principle will also be

For a large part of the work which I have done so far I am indebted to the noble generosity of Mr. J. P. Morgan, which was all the more welcome and stimulating, as it was extended at a time when those who have since promised most were the greatest of doubters. I have also to thank my friend, Stanford White, for much unselfish and valuable assistance. This work is now far advanced, and though the results may be tardy, they are sure to come.

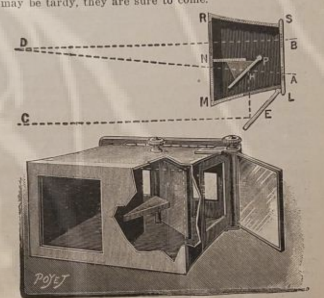


FIG. 1.—BELLIENI'S APEDIOSCOPE FOR OBSERVING STEREOSCOPIC PROJECTIONS.

Meanwhile, the transmission of energy on an industrial scale is not being neglected. The Canadian Niagara Power Company have offered me a splendid inducement, and next to achieving success for the sake of the art, it will give me the greatest satisfaction to make their concession financially profitable to them. In this first power plant, which I have been designing for a long time, I propose to distribute ten thousand horse-power under a tension of one hundred million volts, which I am now able to produce and handle with safety.

The energy will be collected all over the globe, preferably in small amounts, ranging from a fraction of one to a few horse-power. One of its chief uses will be the illumination of isolated homes. It takes very little power to light a dwelling with vacuum tubes operated by high-frequency currents, and in each instance a terminal a little above the roof will be sufficient. Another valuable application will be the driving of clocks and other such apparatus. These clocks will be exceedingly simple, will require absolutely no

tion and manufacture such as have never presented themselves before.

Knowing the far-reaching importance of this first attempt and its effect upon future development, I shall proceed slowly and carefully. Experience has taught me not to assign a term to enterprises the consummation of which is not wholly dependent on my own abilities and exertions. But I am hopeful that these great realizations are not far off, and I know that when this first work is completed they will follow with mathematical certitude.

When the great truth accidentally revealed and experimentally confirmed is fully recognized, and this planet, with all its appalling immensity, is to electric currents virtually no more than a small metal ball, and that by virtue of this fact many possibilities, each baffling imagination and of incalculable consequence, are rendered absolutely sure of accomplishment; when the first plant is inaugurated and it is shown that a telegraphic message, almost as secret and non-interferable as a thought, can be transmitted to any terrestrial distance, the sound of the human voice, with all its intonations and inflections faithfully and instantly reproduced at any other point of the globe, the energy of a waterfall made available for supplying light, heat or motive power, anywhere—on sea, or land, or high in the air—humanity will be like an antheap stirred up with a stick. See the excitement coming!

STEREOSCOPIC PROJECTIONS.

IN order that images may be seen in relief by stereoscopic projections, it does not suffice to project upon the screen the two images emanating from a stereoscopic negative, but it is also necessary that it shall be possible for each eye of the spectator, through an appropriate arrangement, to receive only that one of the two images that is designed for it. There exists a stereoscope for images of large dimensions, and that is the mirror apparatus of M. Cazes; but this is not easily manipulated and cannot be employed by the spectators at an ordinary exhibition of stereoscopic lantern slides. Other inventors, and M. Knight especially, have indicated the possibility of constructing portable apparatus on the same principle. We do not know whether or not the idea was ever carried out, but it appears, at all events, to have fallen into oblivion. Quite recently, M. Bellieni, taking up the same idea, and without knowing anything at all about the work of M. Knight, has succeeded in constructing the apedioscope, a small and easily portable apparatus of moderate price, with which each spectator may provide himself when a lecture, for example, is illustrated with stereoscopic projections. Experimented with recently at a meeting of the French Photographic Society, in which the inventor placed thirty of these apparatus at the disposal of the members, it gave excellent results.

Use is made of the stereoscopic positive upon glass, such as is found in the collections for the ordinary stereoscope (care being taken to remove the ground

of the human nerve mechanism. The influence of this principle on the transmission of intelligence, and electrical energy in general, cannot as yet be estimated, for the art is still in the embryonic stage; but many thousands of simultaneous telegraphic and telephonic messages, through one single conducting channel, natural or artificial, and without serious mutual interference, are certainly practicable, while millions are possible. On the other hand, any desired degree of individualization may be secured by the use of a great number of co-operative elements and arbitrary variation of their distinctive features and order of succession. For obvious reasons, the principle will also be valuable in the extension of the distance of transmission.

Progress, though of necessity slow, was steady and sure, for the objects aimed at were in a direction of my constant study and exercise. It is, therefore, not astonishing that before the end of 1899 I completed the task undertaken and reached the results which I have announced in my article in the Century Magazine of June, 1900, every word of which was carefully weighed.

Much has already been done toward making my system commercially available, in the transmission of energy in small amounts for specific purposes, as well as on an industrial scale. The results attained by me have made my scheme of intelligence transmission, for which the name of "world telegraphy" has been suggested, easily realizable. It constitutes, I believe, in its principle of operation, means employed, and capacities of application, a radical and fruitful departure from what has been done heretofore. I have no doubt that it will prove very efficient in enlightening the masses, particularly in still uncivilized countries and less accessible regions, and that it will add materially to general safety, comfort, and convenience, and maintenance of peaceful relations. It involves the employment of a number of plants, all of which are capable of transmitting individualized signals to the uttermost confines of the earth. Each of them will be preferably located near some important center of civilization and the news it receives through any channel will be flashed to all points of the globe. A cheap and simple device, which might be carried in one's pocket, may then be set up somewhere on sea or land, and it will record the world's news or such special messages as may be intended for it. Thus the entire earth will be converted into a huge brain, as it were, capable of response in every one of its parts. Since a single plant of but one hundred horse-power can operate hundreds of millions of instruments, the system will have a virtually infinite working capacity, and it must needs immensely facilitate and cheapen the transmission of intelligence.

The first of these central plants would have been already completed had it not been for unforeseen delays which, fortunately, have nothing to do with its purely technical features. But this loss of time, while vexatious, may after all prove to be a blessing in disguise. The best design of which I knew has been adopted, and the transmitter will emit a wave complex of a total maximum activity of ten million horse-power, one per cent of which is amply sufficient to "girdle the globe." This enormous rate of energy delivery, approximately twice that of the combined falls of Niagara, is obtainable only by the use of certain artifices, which I shall make known in due course.

safety.

The energy will be collected all over the globe, preferably in small amounts, ranging from a fraction of one to a few horse-power. One of its chief uses will be the illumination of isolated homes. It takes very little power to light a dwelling with vacuum tubes operated by high-frequency currents, and in each instance a terminal a little above the roof will be sufficient. Another valuable application will be the driving of clocks and other such apparatus. These clocks will be exceedingly simple, will require absolutely no

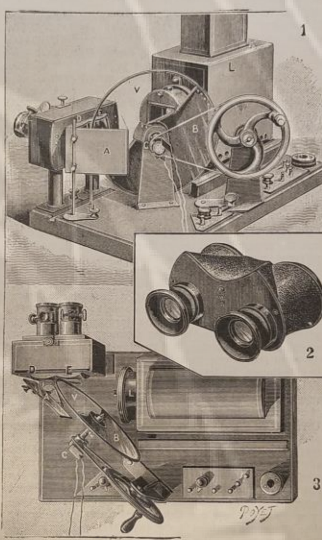


Fig. 2.—THE SCHMIDT AND DUPUIS APPARATUS AND OPERA GLASS FOR OBSERVING STEREOSCOPIC PROJECTIONS.

attention, and will indicate rigorously correct time. The idea of impressing upon the earth American time is fascinating and very likely to become popular. There are innumerable devices of all kinds which are either now employed or can be supplied, and by operating them in this manner I may be able to offer a great convenience to the whole world with a plant of no more than ten thousand horse-power. The introduction of this system will give opportunities for inven-

but it appears, at all events, to have fallen into oblivion. Quite recently, M. Bellieni, taking up the same idea, and without knowing anything at all about the work of M. Knight, has succeeded in constructing the apedioscope, a small and easily portable apparatus of moderate price, with which each spectator may provide himself when a lecture, for example, is illustrated with stereoscopic projections. Experimented with recently at a meeting of the French Photographic Society, in which the inventor placed thirty of these apparatus at the disposal of the members, it gave excellent results.

Use is made of the stereoscopic positive upon glass, such as is found in the collections for the ordinary stereoscope (care being taken to remove the ground glass if any exists). This is passed into a single-objective lantern. A 6-inch condenser suffices for 3¼ x 6½-inch slides, and a 4¾-inch one for 2¼ x 5-inch slides.

The two images are thus projected upon the screen, one alongside of the other. In order to answer the requirements of the principle mentioned above, the spectator's apparatus consists of a small box, *M R S L*, containing two apertures, *A* and *B*, situated at the normal distance apart of the eyes (Fig. 1). Through one of these, *B*, we see directly with the right eye, for instance, one of the two images, *D*, which is the one intended for that eye. The other image, *C*, is concealed from the right eye by a wooden partition, *N P*, placed in the apparatus. But this other image is reflected in a small mirror, *E*, situated upon the other side of the box, and capable of being set in the proper position by means of a button. After the image, *C*, is properly perfected by this mirror, it is received by a second mirror, *H*, placed in the interior of the apparatus. It is here that the right eye, placed at *A*, sees it appear, and instinctively transfers it to *D*, beyond the mirror superposing it upon the first image. This gives the effect of reliefs, as in the ordinary stereoscope.

The slight regulation necessary for the proper reception of one of the images in the mirror is done once for all at the beginning of the lecture or other entertainment by means of a geometrical figure, for example, of which only a part need be projected on each side, but of which the superposition must be made to appear complete. It is to be remarked that this system occasions no loss of light.

There are still other methods of viewing stereoscopic lantern slides in relief. This question was discussed by us thirteen years ago, when M. Molteni projected the two images one upon the other, after having colored one of them red and the other green, by means of colored glasses placed before them. The spectators had to be provided with eye-glasses having the same colors. It is evident that, under such circumstances, each eye can see only the image that is designed for it, and the relief is easily perceived. But these multicolored screens upon the lantern and the eyes absorb too great a quantity of light, and that is what has prevented the development of this system of stereoscopic projection.

The idea has been taken up under another form by various persons, and, among others, by M. Rateau; and we have recently seen it carried out in a very complete manner by MM. Schmidt and Dupuis. The process consists in projecting the two images successively. If the spectator opens but one eye at a time—the left

537

SCIENTIFIC AMERICAN

1845 — 70th Anniversary Number — 1915

Vol. CXII. No. 23
June 5, 1915

Munn & Co., Inc., Publishers
New York, N. Y.

Price 25 Cents
$3.00 A Year

SEVENTY-FIRST YEAR

SCIENTIFIC AMERICAN

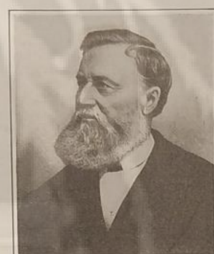
THE WEEKLY JOURNAL OF PRACTICAL INFORMATION

VOLUME CXII.
NUMBER 23.

NEW YORK, JUNE 5, 1915

25 CENTS A COPY
$3.00 A YEAR

Gordon McKay, inventor of the McKay shoe-making machines.

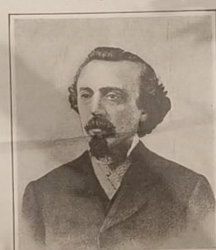


Isaac Singer, inventor of the Singer sewing machine.

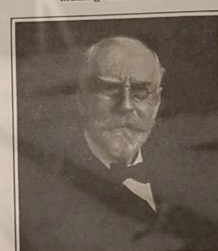
Lyman E. Blake, inventor of shoe-making machinery.

Charles Goodyear, inventor of the Goodyear lasting machinery.

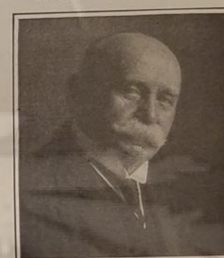
Joseph Henry, who laid the foundation of the electric telegraph.



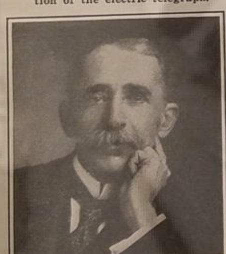
Charles J. Vandepoele, inventor of American overhead trolley system.



Dr. Coleman Sellers, pioneer motion picture and machine tool inventor.



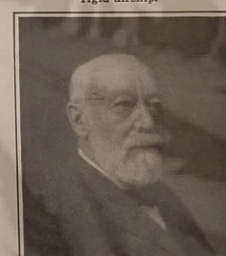
Count von Zeppelin, inventor of the rigid airship.



Prof. J. A. Fleming, inventor of the electric valve used in wireless.

James Gayley, inventor of the dry-blast process of steel making.

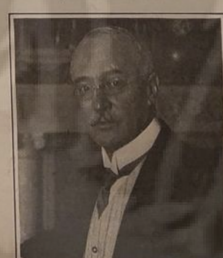
Charles E. Scribner, inventor of telephone switchboards.



J. S. Hyatt, an industrial chemist, who discovered celluloid.

Frank Sprague, inventor of the multiple unit system of train control.

Charles G. Curtis, inventor of the Curtis steam turbine.

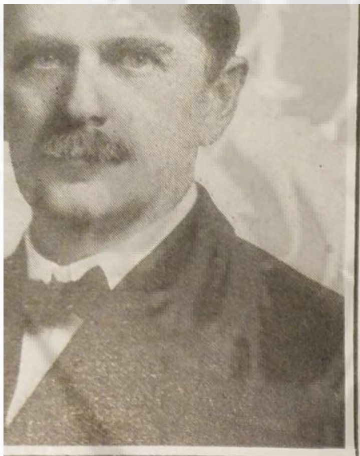


Copyright by Edwin Levick

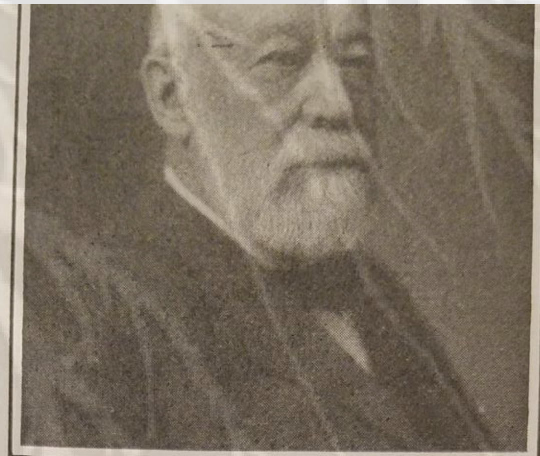
Dr. Rudolf Diesel, inventor of the Diesel engine.

Charles P. Steinmetz, inventor of the magnetite arc.

SOME GREAT INVENTORS OF THE PAST SEVEN DECADES



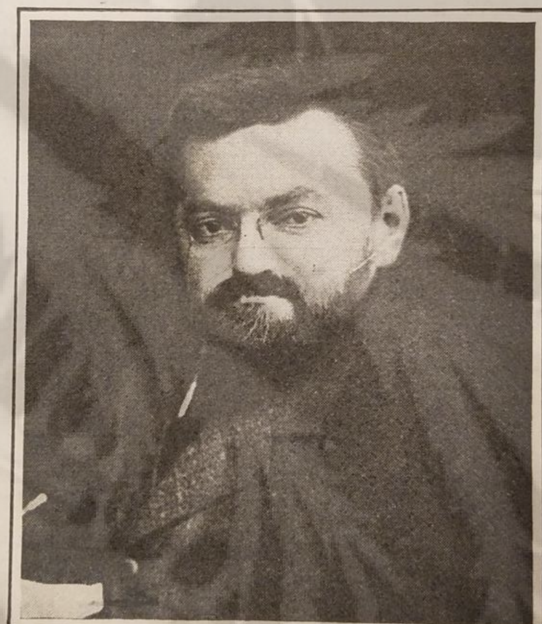
cribner, inventor of tele-
ne switchboards.



J. S. Hyatt, an industrial chemist, who discovered celluloid.

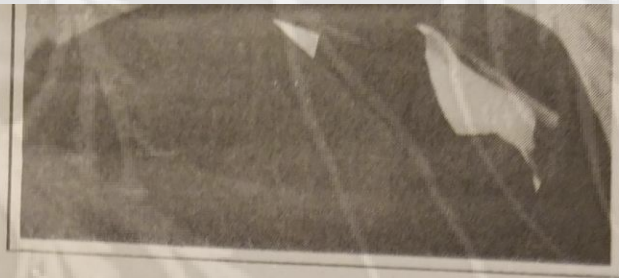
Levick

Diesel, inventor of the
Diesel engine.

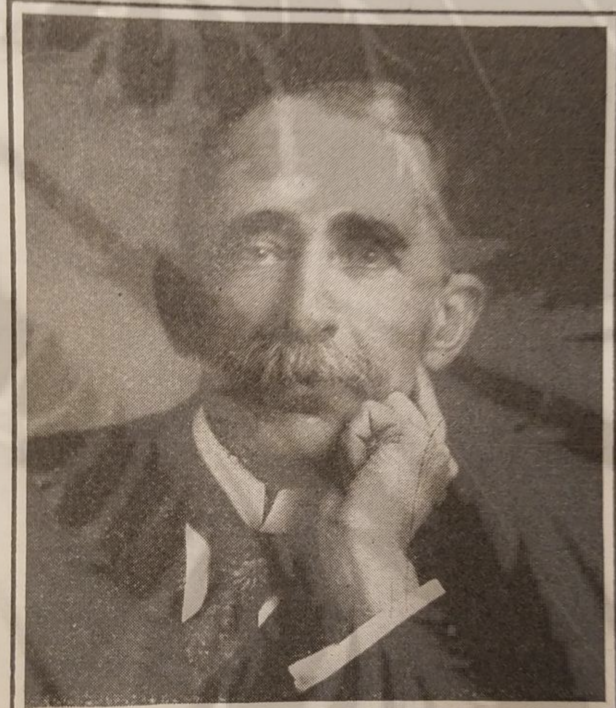


Charles P. Steinmetz, inventor of the magnetite arc.

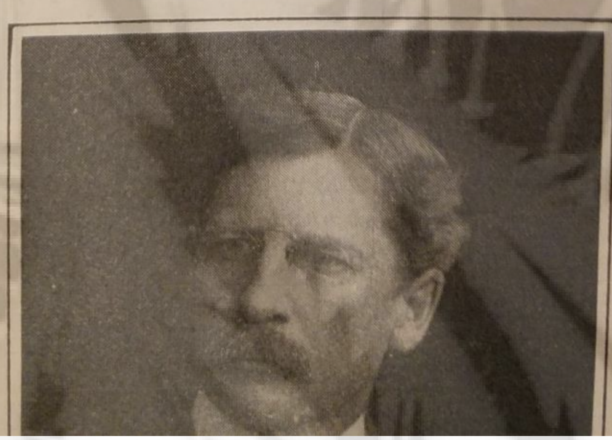
SEVEN DECADES

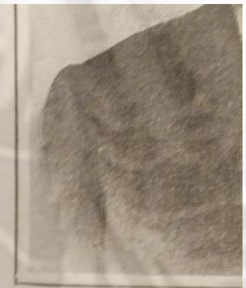


Joseph Henry, who laid the foundation of the electric telegraph.



Prof. J. A. Fleming, inventor of the electric valve used in wireless.





**Charles J. Va
American ove**

**James Gayley,
blast process**

roduct. Two Englishmen, Anthony
he idea of splitting a web of paper
halves and transferring one half
ner by means of deflecting bars, so
roduct of a printing cylinder could
ts left-hand product and the two
This invention is now included in
spaper printing presses. Another
when Ford patented a means for
of two printing machines into one
he ro-
ll (or
g cyl-
nethod
s ar-
neces-
paper
e pos-
Com-
com-
struc-
other
out of
y val-
made
enious
could
awing
n pat-
th no
he de-
longi-
nich a
longi-
e run
About
1889)
ea of
as the
to the
copies-
s, and
ed (in
he ro-
inting
ments
it is

Did
nd

s in
a d e.
y had
n bes-
(1877-
experiments of Semennikow, M. J.
ucceeded in blowing Rio Tinto ores
rs.
by-product coke oven, an improve-
r and Hoffmann, was introduced in
has served as the inspiration of

cCosh invented the so-called Gart-
obtaining ammonia and tar from
The first proposal to utilize waste
fer the generation of power seems
by Josef von Ehrenwerth in 1883.

which could be directly coupled with a dynamo.

In the same year Pelton, an American, invented the Pelton wheel, in which cups are used instead of blades, the cups being so designed that they utilize the force of the impinging water to the utmost.

Mergenthaler and His Linotype.

For many decades inventors had endeavored to supply a satisfactory machine which would rapidly set type and which would enable newspaper proprietors to turn out papers more rapidly than was possible with hand composition. It was not until 1888 that such a ma-

Some of Edison's work in the decade 1875-1885.

chine was invented. It was the invention of Ottmar Mergenthaler, and it worked on an entirely new principle. Instead of seeking to set the types and after their use to distribute them among their respective receptacles in order that they might be automatically composed—the principle on which previous inventors had worked—Mergenthaler composed the type-matrices, and from these cast, as a single piece, a line of characters. Hence, his machine was called a "linotype." Mergenthaler's matrix was of brass, flat and rectangular, having a V-shaped notch cut deep into its upper end, the edges of the notch being lined with small hook-like projections.

was drawn through the machine, t
frame properly and set the mold
needed, while the pump and co-opera
cast the character and place it in it
a tray, or "galley," at the rate o
minute.

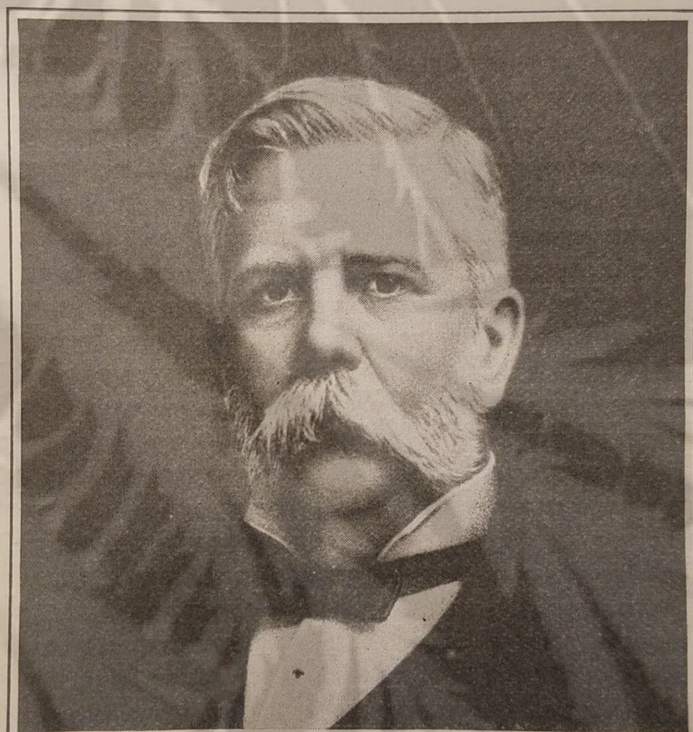
The Invention of the Au

The first really successful moder
bon automobile appeared in 1883.
built by Gottlieb Daimler. His su
been due very largely to his autom
which
both s
able
motors
of Roc
for a
hydro
1876,
until
paten
years
must
of ha
ern a
it. M
to Ka
who
four-
carbo
ignit
moun
thou
1885
until
Indu
Mun

Imp

In
buil
(the
lowi
of c
hori
was
whi
unde
ably
torp
wor
sign
prec
ever
of
vess
by
being given off at gradually re
Garrett became associated with
new ideas, among them down-ha
ships either side of the vessel t
By varying the speed of the s
of submergence could be contro
submarines for Turkey, Greece,
internal torpedo firing tubes w
time.

In 1880 Alexander E. Brown
chanical ore unloader to take
boat and deliver it either to car
out rehandling, an invention th



George Westinghouse, whose invention of the air-brake made modern high-speed railway travel possible.

the original machine itself being still used in electric testing. It is described in patent 432,655 of July 22nd, 1890.

An important invention bearing on interpole work, now such a decided factor in the construction of dynamos and motors for continuous currents is shown in patent 459,422, filed in 1885 and issued September 15th, 1891. This dynamo appears to be a pioneer invention in that the separation of the series and shunt coils on the field for securing better commutation and at the same time compounding a machine, are found. The

that the effect
weakness of th
vaal took up
introduced.

The first con
artificial silk w
net, who squirt
small holes in
the threads co

John B. Dun
the pneumatic
seems to have
work in the sa

Artificial

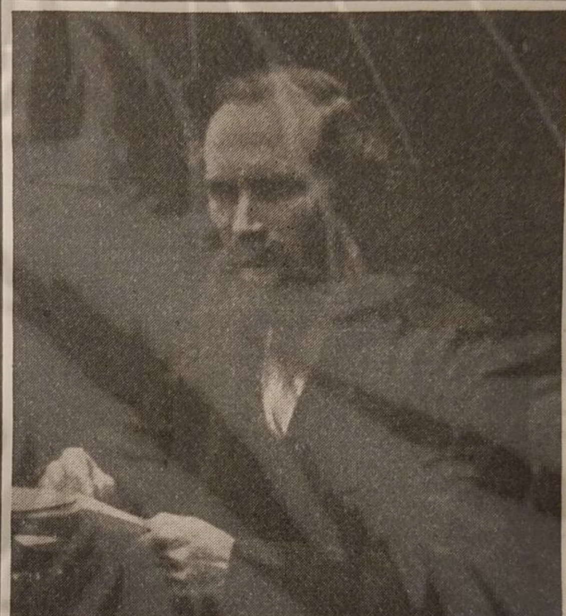
Experiments
away some of
interested in a
of Berlin bega
less aeroplane
ley and Max
was killed in
Langley in 1
motor-driven
his experimen
of his failed
in the launc
cessfully flow
Hiram Maxin
enormous pro
360 horse-pow
distance, it ca
rails which w

Edison's ex
graph of 187
able investiga
others. In 1
ner Tainter p

Great

lephone and

to Marconi



Sir William Thomson (later Lord Kelvin) inventor of the siphon recorder.

at each end, or eight in all. Aside from other material advantages it is estimated that at least from $15,000,000 to $20,000,000 has been saved by the Edison quadruplex, merely in the cost of line construction in America.

Another system of multiple transmission was proposed by Moses G. Farmer of Salem, Mass., in 1852, in which by a commutating arrangement the main line was put in rapid succession in contact with a series of branch wires by proper

Copyright Harris & Ewing

by which
submarine
joyed in the
es on over-
smission at
siphon re-
rse recorder

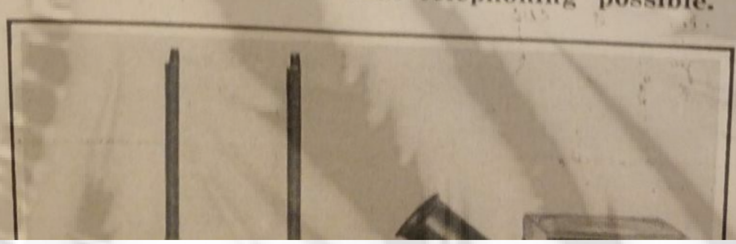
has involved
nent signals
In Gott's
nt is effected
elay through
of the cur-
With this
an Francisco
ile the meth-
ual speed of
phy more ac-

aphs.

ventors have
with printing
stupid and
ls of printing
of the twen-
udot and the
. With the
was compara-
rk only over
was desirable,
by playing on
a considerable
o necessity to
the number of
the messages
aph blanks, no
record, or put
opes and send

Copyrighted by Brown Bros.

Prof. Michael I. Pupin, inventor of the load coil that made transcontinental telephoning possible.



keyboard.
The Baudot
France, and
pean capital
it is equiva
working over
practical, an
but it is not
cause it is
transmitting,
It prints on
preciable ext
virtue is tha
neighboring c
that has been
quadruplex.
be described
modern telegr
developed ma
1900. Within
Virag, Buckin
mens and Ha
companies and
toward machin

Alexande

The inventi
greatest adva
communicatin
that sound is
er to hearer b
faction, which
1831 Wheatsto
transmitted fr
distance throu
to the air by th
of the rod. S
phragm to prod
other diaphragm
rents was the
first to propose
seul, who in 185
at the transmitt

... the father of the
ich he was thus, like L..ws,
nd exploit the under..ying
ion as a universal source
rmed his indicator into a
ted record. At this junc-
In collabor-
a one-wire
Lefferts he
icker. The
widespread
Since then
e devotion
M. Phelps,
udson, G.
hn Burry
as an ap-
or com-
ificant of
overlaid
ry outset
ce of in-
n of this

ing tele-
-day in
ed stock
ld Mur-
ntor in

of Washington.

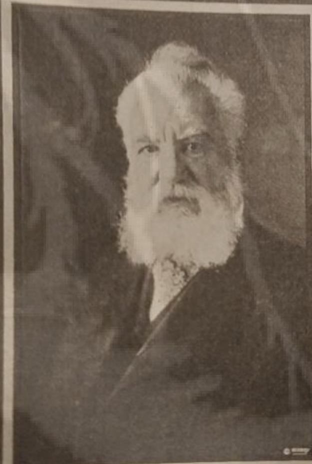
this field. In a paper which he published some years ago he summarized the whole situation excellently as follows:

"The Hughes instrument prints on a tape, and the speed is limited by the manual dexterity of the operator and the

Marconi and one of his early wireless sets.

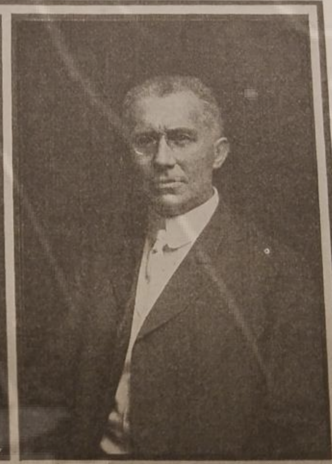
one side of a box, with
piece the sounds could
was made to open and cl
vibration. At the receivi
sisting of a thin rod of
placed. The successive
the electric circuits too
discovery
Mass., in 1
There is
Reis's tele
probably
His metho
speaking s
characteris
not only co
loudness a
transmitter
which did
such inter
which vari
manner si
sure on th
It was n
produced h
requiremen
oughly un
antly clear
of his ea
(

original Centennial iron box receiver.



Alexander Graham Bell.

Copyright Harris & Ewing



Emile Berliner.

The first instrumen

d, invented a new method by which
can be sent through long submarine
e approach to the facility enjoyed in the
f the familiar dots and dashes on over-
The method obviates retransmission at
ends, and eliminates the siphon re-
Morse recorder

keyboard. The gain co
The Baudot printing t
France, and which conn
pean capitals, may be
it is equivalent to fou
working over a single w
practical, and gives ad
but it is not a fully d
cause it is not provi
transmitting and it do

& Sims high speed engine is employed
The line shaft is placed in the lower
house; it is six inches in diameter and
iving all the dynamos. It is not connect-
gines, but the latter are belted to jack
nafts, through which the main shaft
nected to the latter by friction clutches;
eing a Hill clutch 54 inches in diame-
ansmitting 500 h. p.
is 60 feet wide and 200 feet long,
ing nearly 30 feet, thus giving, aside
in which the shafting is located,
et high to the underside of the truss
oof of the engine house, is of wrought
in Iron Bridge Company. The dyna-
floor of the building, just above the
number 41; 35 of them are Thom-
amos with a total capacity of 1,450
1,300 are in circuit. The incandes-
presided over by five Westinghouse
an aggregate output of 10,500 lamps,
0 are in circuit. The incandescent
ly by meter. Besides this a 500 volt
erator is operated on a motor circuit
nes with a total capacity of 229 h. p.
pany include, all told, 300 miles of
nodel of its kind. This brief sketch
f the many good points of what is in
el station. It furnishes the most
played at the present meeting of the
Association.

y of Transformers.

LIAM STANLEY, JR.

ken from tests made at the Stanley
may be of interest to engineers.
resumably of the latest design, as
d obtained from the manufacturer
days. The method adopted for
and Foucault losses was the sam
esley, known as Blakesley's split
determining lag, which, while it
ot be relied upon for very accurate
iently proximate for commercial
able basis of comparison between
s. It is unfortunate that two of

Phenomena of Alternating Currents of Very High Frequency.

BY NIKOLA TESLA.

ALTERNATE CURRENT MACHINES OF HIGH FREQUENCY; CURIOUS EXPERIMENTS WITH GEISSLER TUBES AND LAMPS; AN EXPLODED NOTION; NOISELESS ALTERNATING ARCS; CONSTANT CURRENT AND CONSTANT POTENTIAL; INTERESTING EXPERIMENT WITH A CONDENSER; THE FERRANTI-MAIN EFFECT; DA LIEGT DER HASE IM PFEFFER BEGRABEN; SUGGESTIONS OF MR. SWINBURNE.

Electrical journals are getting to be more and more interesting. New facts are observed and new problems spring up daily which command the attention of engineers. In the last few numbers of the English journals, principally in the *Electrician*, there have been several new matters brought up which have attracted more than usual attention. The address of Professor Crookes has revived the interest in his beautiful and skillfully performed experiments, the effect observed on the Ferranti mains has elicited the expressions of opinion of some of the leading English electricians, and Mr. Swinburne has brought out some interesting points in connection with condensers and dynamo excitation.

The writer's own experiences have induced him to venture a few remarks in regard to these and other matters, hoping that they will afford some useful information or suggestion to the reader.

Among his many experiments Professor Crookes shows some performed with tubes devoid of internal electrodes, and from his remarks it must be inferred that the results obtained with these tubes are rather unusual. If this be so, then the writer must regret that Professor Crookes, whose admirable work has been the delight of every investigator, should not have availed himself in his experiments of a properly constructed alternate current machine —namely, one capable, of giving, say, 10,000 to 20,000 alternations per second. His researches on this difficult but fascinating subject would then have been even more complete. It is true that when using such a machine in connection with an induction coil the distinctive character of the electrodes—which is desirable, if not essential, in many experiments—is lost, in most cases both the electrodes behaving alike; but, on the other hand, the advantage is gained that the effects may be exalted at will. When using a rotating switch or commutator the rate of change obtainable in ...

... the writer, the discharge of even a very large coil cannot produce seriously injurious effects, whereas, if the same coil were operated with a current of lower frequency, though the electromotive force would be much smaller, the discharge would be most certainly injurious. This result, however, is due in part to the high frequency. The writer's experiences tend to show that the higher the frequency the greater the amount of electrical energy which may be passed through the body without serious discomfort; whence it seems certain that human tissues act as condensers.

One is not quite prepared for the behavior of the coil when connected to a Leyden jar. One, of course, anticipates that since the frequency is high the capacity of the jar should be small. He therefore takes a very small jar, about the size of a small wine-glass, but he finds that even with this jar the coil is practically short-circuited. He then reduces the capacity until he comes to about the capacity of two spheres, say, ten centimetres in diameter and two to four centimetres apart. The discharge then assumes the form of a serrated band exactly like a succession of sparks viewed in a rapidly revolving mirror; the serations, of course, corresponding to the condenser discharges. In this case one may observe a queer phenomenon. The discharge starts at the nearest points, works gradually up, breaks somewhere near the top of the spheres, begins again at the bottom, and so on. This goes on so fast that several serrated bands are seen at once. One may be puzzled for a few minutes, but the explanation is simple enough. The discharge begins at the nearest points, the air is heated and carries the arc upward until it breaks, when it is re-established at the nearest points, etc. Since the current passes easily through a condenser of even small capacity, it will be found quite natural that connecting only one terminal to a body of the some size, no matter how well insulate , impairs considerably the striking distance of the arc.

Experiments with Geissler tubes are of special interest. An exhausted tube, devoid of electrodes of any kind, will light up at some distance from the coil. If a tube from a vacuum pump is near the coil the whole of the pump is brilliantly lighted. An incandescent lamp approached to the coil lights up and gets perceptibly hot. If a lamp have the terminals connected to one of the binding posts of the coil and the hand is ... a very curious ...

or less parallel with that lin
the brilliancy of the tube
Numerous other phenomen
assumption. For instance,
vided with washers of suff
joining the terminals of
as then nearly the who
otherwise pass uniforml
the washers, is diverted
tube be inclined suffici
up in spite of the washe
ened upon a glass rod a
joining the binding posts
held more or less parall
stantly when one of it
will go out when separ
the surface of the plate
tube will light up. W
to the straight line jo
tated, its luminosity s
with that line. The
does not favor the ide
space any more than
convinced that all t
formed with a static
ence of potential, ar
cerned in these phe
It is well to take
Ruhmkorff coil w
The primary curre
the core may get
paraffin, or otherw
occur in a surprisi
considered. The
fine wire terminal
impedence being
current through
fact the coil may
minals of the fin
insulated; but sp
minals are conne
anywhere near
acts the self-ind
might meet the
vacuum pump
touched with a
current should

ce is entirely by meter. Besides this a ...
Iouston generator is operated on a motor circuit
ig 88 machines with a total capacity of 229 h. p.
of the company include, all told, 300 miles of
k that is a model of its kind. This brief sketch
ough idea of the many good points of what is in
ts a model station. It furnishes the most
exhibit displayed at the present meeting of the
ectric Light Association.

Efficiency of Transformers.

BY WILLIAM STANLEY, JR.

ing data, taken from tests made at the Stanley
t Pittsfield, may be of interest to engineers.
ners are presumably of the latest design, as
ely new, and obtained from the manufacturer
ast thirty days. The method adopted for
hysteresis and Foucault losses was the sam
by Blakesley, known as Blakesley's split
method of determining lag, which, while it
and cannot be relied upon for very accurate
s, is sufficiently proximate for commercial
rds a reliable basis of comparison between
ransformers. It is unfortunate that two of
ers were of larger size than the others, for it
ly easy to design a 1,200-watt transformer
fficiency one per cent. greater than a 1,000-
ner designed with equal care would have
f the active iron in the transformers tested
cent. for a given output. It should be borne
the column marked "maximum efficiency"
ality lower values than actually are obtained
ause the total loss in a transformer is not the
by hysteresis and the C^2R losses, measured
rmer is doing no work, but is less than the
ses, because the hysteresis loss falls off as the
d upon the secondary, and generally that
not intended for more than comparative
ansformers tested converted from 1,000 to
tested, save the Thomson-Houston trans-
rent was taken from one of the Westing-
's alternators at a frequency of 138 periods
the case of the Thomson-Houston trans-
tested with the current from a Thomson
e at 125 periods per second.
es the type and size of transformer; column
assing through the transformer when the
pen; column 3, the potential on the prim-
the C^2R loss in primary and secondary
5, the percentage drop below normal po-
condary circuit at full load; column 6, the
oucault losses; column 7, the efficiencies at
ted from columns 4 and 6 together. A sched-
ts of the transformers is appended. It is
ice that the watts lost per pound of iron in
ers varies from 1.1 watts to .3 watt per
been mentioned, the size of the transform-
tant item in estimating its efficiency. The
rked "Slattery," 25-light size (1,250 watts),
um efficiency of 94.0 per cent., principally
f 25 per cent. greater capacity, its copper
ore efficiently used. Certain transformers

dynamo excitation...

The writer's own experiences have ... ture a few remarks in regard to these and other matters, hoping that they will afford some useful information or suggestion to the reader.

Among his many experiments Professor Crookes shows some performed with tubes devoid of internal electrodes, and from his remarks it must be inferred that the results obtained with these tubes are rather unusual. If this be so, then the writer must regret that Professor Crookes, whose admirable work has been the delight of every investigator, should not have availed himself in his experiments of a properly constructed alternate current machine —namely, one capable, of giving, say, 10,000 to 20,000 alternations per second. His researches on this difficult but fascinating subject would then have been even more complete. It is true that when using such a machine in connection with an induction coil the distinctive character of the electrodes—which is desirable, if not essential, in many experiments—is lost, in most cases both the electrodes behaving alike; but, on the other hand, the advantage is gained that the effects may be exalted at will. When using a rotating switch or commutator the rate of change obtainable in the primary current is limited. When the commutator is more rapidly revolved the primary current diminishes, and if the current be increased, the sparking, which cannot be completely overcome by the condenser, impairs considerably the virtue of the apparatus. No such limitations exist when using an alternate current machine, as any desired rate of change may be produced in the primary current. It is thus possible to obtain excessively high electromotive forces in the secondary circuit with a comparatively small primary current; moreover, the perfect regularity in the working of the apparatus may be relied upon.

The writer will incidentally mention that any one who attempts for the first time to construct such a machine will have a tale of woe to tell. He will first start out, as a matter of course, by making an armature with the required number of polar projections. He will then get the satisfaction of having produced an apparatus which is fit to accompany a thoroughly Wagnerian opera. It may besides possess the virtue of converting mechanical energy into heat in a nearly perfect manner. If there is a reversal in the polarity of the projections, he will get heat out of the machine; if there is no reversal, the heating will be less, but the output will be next to nothing. He will then abandon the iron in the armature, and he will get from the Scylla to the Charybdis. He will look for one difficulty and will find another, but, after a few trials, he may get nearly what he wanted.

Among the many experiments which may be performed with such a machine, of not the least interest are those performed with a high-tension induction coil. The character of the discharge is completely changed. The arc is established at much greater distances, and it is so easily affected by the slightest current of air that it often wriggles around in the most singular manner. It usually emits the rhythmical sound peculiar to the alternate current arcs, but the curious point is that the sound may be heard with a number of alternations far above ten thousand per second, which by many is consid...

the top of the spheres, ... bottom, and so on. This goes on so fast that several serrated bands are seen at once. One may be puzzled for a few minutes, but the explanation is simple enough. The discharge begins at the nearest points, the air is heated and carries the arc upward until it breaks, when it is re-established at the nearest points, etc. Since the current passes easily through a condenser of even small capacity, it will be found quite natural that connecting only one terminal to a body of the some size, no matter how well insulate , impairs considerably the striking distance of the arc.

Experiments with Geissler tubes are of special interest. An exhausted tube, devoid of electrodes of any kind, will light up at some distance from the coil. If a tube from a vacuum pump is near the coil the whole of the pump is brilliantly lighted. An incandescent lamp approached to the coil lights up and gets perceptibly hot. If a lamp have the terminals connected to one of the binding posts of the coil and the hand is approached to the bulb, a very curious and rather unpleasant discharge from the glass to the hand takes place, and the filament may become incandescent. The discharge resembles to some extent the stream issuing fr om the plates of a powerful Tœpler machine, but is of incomparably greater quantity. The lamp in this case acts as a condenser, the rarefied gas being one coating, the operator's hand the other. By taking the globe of a lamp in the hand, and by bringing the metallic terminals near to or in contact with a conductor connected to the coil, the carbon is brought to bright incandescence and the glass is rapidly heated. With a 100-volt 10 c. p. lamp one may without great discomfort stand as much current as will bring the lamp to a considerable brilliancy; but it can be held in the hand only for a few minutes as the glass is heated in an incredibly short time. When a tube is lighted by bringing it near to the coil it may be made to go out by interposing a metal plate or the hand between the coil and tube; but if the metal plate be fastened to a glass rod or otherwise insulated, the tube may remain lighted if the plate be interposed, or may even increase in luminosity. The effect depends on the position of the plate and tube relatively to the coil and may be always easily foretold by *assuming* that conduction takes place from one terminal of the coil to the other. According to the position of the plate, it may either divert from or direct the current to the tube.

In another line of work the writer has in frequent experiments maintained incandescent lamps of 50 or 100 volts burning at any desired candle power with both the terminals of each lamp connected to a stout copper wire of no more than a few feet in length. These experiments seem interesting enough, but they are not more so than the queer experi ment of Faraday, which has been revived and made much of by recent investigators, and in which a discharge is made to jump between two points of a bent copper wire. An experiment may be cited here which may seem equally interesting. If a Geissler tube, the terminals of which are joined by a copper wire, be approached to the coil...

convinced that ...
formed with a static machine yielding a
ence of potential, and that condenser acti
cerned in these phenomena.
It is well to take certain precautions
Ruhmkorff coil with very rapidly alte
The primary current should not be turne
the core may get so hot as to melt th
paraffin, or otherwise injure the insula
occur in a surprisingly short time, the
considered. The primary current be
fine wire terminals may be joined wit
impedence being so great that it is diffi
current through the fine wire so as
fact the coil may be on the whole muc
minals of the fine wire are connected
insulated; but special care should be
minals are connected to the coatings of
anywhere near the critical capacity
acts the self-induction at the existi
might meet the fate of St. Polycar
vacuum pump is lighted up by bei
touched with a wire connected to o
current should be left on no more th
the glass will be cracked by the he
in one of the narrow passages—in
rience *quod erat demonstrandum.*
There are a good many other p
may be observed in connection wi
periments with the telephone, a c
or with a condenser or arc seem
that sounds far above the usual a
would be perceived. A telephon
to thirteen thousand vibrations p
of the core to follow such rapid
If, however, the magnet and co
ser and the terminals connected
ary of a transformer higher not
current be sent around a finely
piece of thin sheet iron be hel
sound may be still heard with
sand alternations per second,
ficiently strong. A small coil,
tween the poles of a powerful
with the above number of a
audible with still a highe
audition is variously es
Thomson's writings it is
thousand per second, or ne
but less reliable, sources
four thousand per secon
have convinced the wri
parably higher number of
perceived provided they co
power. There is no reason
condensations and rarefacti
set the diaphragm in a co
sensation would be produce
—the velocity of transmissi
it is probable that for wa
be able to distinguish any
it is different: if the sens

l affords a reliable basis of comparison between
ral transformers. It is unfortunate that two of
formers were of larger size than the others, for it
atively easy to design a 1,200-watt transformer
an efficiency one per cent. greater than a 1,000-
isformer designed with equal care would have·
hts of the active iron in the transformers tested
) per cent. for a given output. It should be borne
hat the column marked "maximum efficiency"
in reality lower values than actually are obtained
e, because the total loss in a transformer is not the
e loss by hysteresis and the C^2R losses, measured
performer is doing no work, but is less than the
se losses, because the hysteresis loss falls off as the
reased upon the secondary, and generally that
are not intended for more than comparative
ll transformers tested converted from 1,000 to
In all tested, save the Thomson-Houston trans-
e current was taken from one of the Westing-
pany's alternators at a frequency of 138 periods
l. In the case of the Thomson-Houston trans-
was tested with the current from a Thomson
achine at 125 periods per second.

l gives the type and size of transformer; column
ent passing through the transformer when the
was open; column 3, the potential on the prim-
n 4, the C^2R loss in primary and secondary
lumn 5, the percentage drop below normal po-
he secondary circuit at full load; column 6, the
nd Foucault losses; column 7, the efficiencies at
timated from columns 4 and 6 together. A sched-
eights of the transformers is appended. It is
o notice that the watts lost per pound of iron in
formers varies from 1.1 watts to .3 watt per
has been mentioned, the size of the transform-
nportant item in estimating its efficiency. The
marked "Slattery," 25-light size (1,250 watts),
ximum efficiency of 94.0 per cent., principally
ng of 25 per cent. greater capacity, its copper
e more efficiently used. Certain transformers
the writer of 1,500-watt capacity exceed 96 per
cy estimated on the same basis as those in the

viz., that the efficiency of a transformer is a
its capacity, clearly indicates that the trans-
arge capacity should be in general use, as it is
ly easy to design them of 5,000 to 10,000 watts
an efficiency of 97½ per cent., while it is far
lt to design a 250-watt transformer at an effi-
per cent.

Size.	Leakage cur.	E. M. F.	Total C^2R.	Drop.	Hys.	Max. eff.
0-light	.053 amp.	1,000 volts.	19.25	1.9	37.5	94.3
0 "	.061 "	1,000 "	20.8	2.1	48.	93.1
5 "	.056 "	1,000 "	30.2	2.*	45.5	94.
0 "	.112 "	1,000 "	24.8	2.4	75.	90.1
5 "	.213 "	1,000 "	27.	1.8	129.3	87.5

..... Stanley	(20-light)	46 pounds	(without case.)
..... Slattery	(25-light)	121	"
..... National	(20-light)	81	"
..... T.-H.	(25-light)	145	"
..... W'house	(20-light)	85	"

physiological effect! →

tor the rate of change obtaina... is more rapidly re... limited. When the commutator diminishes, and if the current be increased, the sparking, which cannot be completely overcome by the condenser, impairs considerably the virtue of the apparatus. No such limitations exist when using an alternate current machine, as any desired rate of change may be produced in the primary current. It is thus possible to obtain excessively high electromotive forces in the secondary circuit with a comparatively small primary current; moreover, the perfect regularity in the working of the apparatus may be relied upon.

The writer will incidentally mention that any one who attempts for the first time to construct such a machine will have a tale of woe to tell. He will first start out, as a matter of course, by making an armature with the required number of polar projections. He will then get the satisfaction of having produced an apparatus which is fit to accompany a thoroughly Wagnerian opera. It may besides possess the virtue of converting mechanical energy into heat in a nearly perfect manner. If there is a reversal in the polarity of the projections, he will get heat out of the machine; if there is no reversal, the heating will be less, but the output will be next to nothing. He will then abandon the iron in the armature, and he will get from the Scylla to the Charybdis. He will look for one difficulty and will find another, but, after a few trials, he may get nearly what he wanted.

Among the many experiments which may be performed with such a machine, of not the least interest are those performed with a high-tension induction coil. The character of the discharge is completely changed. The arc is established at much greater distances, and it is so easily affected by the slightest current of air that it often wriggles around in the most singular manner. It usually emits the rhythmical sound peculiar to the alternate current arcs, but the curious point is that the sound may be heard with a number of alternations far above ten thousand per second, which by many is considered to be about the limit of audition. In many respects the coil behaves like a static machine. Points impair considerably the sparking interval, electricity escaping from them freely, and from a wire attached to one of the terminals streams of light issue, as though it were connected to a pole of a powerful Toepler machine. All these phenomena are, of course, mostly due to the enormous differences of potential obtained. As a consequence of the self-induction of the coil and the high frequency, the current is minute while there is a corresponding rise of pressure. A current impulse of some strength started in such a coil should persist to flow no less than four ten-thousandths of a second. As this time is greater than half the period it occurs that an opposing electromotive force begins to act while the current is still flowing. As a consequence, the pressure rises as in a tube filled with liquid and vibrated rapidly around its axis. The current is so small that, in the opinion and involuntary experience of

fr om the p... of incomparably greater quantity. The lamp in this case acts as a condenser, the rarefied gas being one coating, the operator's hand the other. By taking the globe of a lamp in the hand, and by bringing the metallic terminals near to or in contact with a conductor connected to the coil, the carbon is brought to bright incandescence and the glass is rapidly heated. With a 100-volt 10 c. p. lamp one may without great discomfort stand as much current as will bring the lamp to a considerable brilliancy; but it can be held in the hand only for a few minutes as the glass is heated in an incredibly short time. When a tube is lighted by bringing it near to the coil it may be made to go out by interposing a metal plate or the hand between the coil and tube; but if the metal plate be fastened to a glass rod or otherwise insulated, the tube may remain lighted if the plate be interposed, or may even increase in luminosity. The effect depends on the position of the plate and tube relatively to the coil and may be always easily foretold by *assuming* that conduction takes place from one terminal of the coil to the other. According to the position of the plate, it may either divert from or direct the current to the tube.

In another line of work the writer has in frequent experiments maintained incandescent lamps of 50 or 100 volts burning at any desired candle power with both the terminals of each lamp connected to a stout copper wire of no more than a few feet in length. These experiments seem interesting enough, but they are not more so than the queer experiment of Faraday, which has been revived and made much of by recent investigators, and in which a discharge is made to jump between two points of a bent copper wire. An experiment may be cited here which may seem equally interesting. If a Geissler tube, the terminals of which are joined by a copper wire, be approached to the coil, certainly no one would be prepared to see the tube light up. Curiously enough, it does light up, and, what is more, the wire does not seem to make much difference. Now one is apt to think in the first moment that the impedance of the wire might have something to do with the phenomenon. But this is of course immediately rejected, as for this an enormous frequency would be required. The result, however, seems puzzling only at first; for upon reflection it is quite clear that the wire can make but little difference. It may be explained in more than one way, but it agrees perhaps best with observation to assume that conduction takes place from the terminals of the coil through the space. On this assumption, if the tube with the wire be held in any position, the wire can divert little more than the current which passes through the space occupied by the wire and the metallic terminals of the tube; through the adjacent space the current passes practically undisturbed. For this reason, if the tube be held in any position at right angles to the line joining the binding posts of the coil, the wire makes hardly any difference, but in a position more

curren...
the glass will be cracked by the heating
in one of the narrow passages—in the
rience *quod erat demonstrandum*.*

There are a good many other points
may be observed in connection with s
periments with the telephone, a cond
or with a condenser or arc seem to
that sounds far above the usual accep
would be perceived. A telephone wil
to thirteen thousand vibrations per se
of the core to follow such rapid alter
If, however, the magnet and core be
ser and the terminals connected to th
ary of a transformer higher notes m
current be sent around a finely lami
piece of thin sheet iron be held ge
sound may be still heard with thir
sand alternations per second, provi
ficiently strong. A small coil, how
tween the poles of a powerful ma
with the above number of altern
audible with still a higher fr
audition is variously estima
Thomson's writings it is state
thousand per second, or nearly
but less reliable, sources give
four thousand per second.
have convinced the writer
parably higher number of vibra
perceived provided they could b
power. There is no reason why
condensations and rarefactions
set the diaphragm in a corresp
sensation would be produced wh
—the velocity of transmission t
it is probable that for want of
be able to distinguish any such
it is different; if the sense of
sonance effect, as many believ
the intensity of the ethereal
range of vision on either side

The limit of audition of an
greater the surface by a given
higher the limit of audition.
by the high-tension discharge
the arc is, so to speak, all sur
of an arc, and C the current,
n times increased, then the r
same current density the cu
heating effect is n^2 times gr
n^2 times as great. For this

* It is thought necessary to
coil may give quite a good res
alternating currents, yet its
iron core, makes it very unfi
obtain the best results the con

...ne is employed
...; it is six inches in diameter and
...driving all the dynamos. It is not connect-
...y to the engines, but the latter are belted to jack
...lleys on hollow shafts, through which the main shaft
...sses. They are connected to the latter by friction clutches:
...e one now used being a Hill clutch 54 inches in diame-
...and capable of transmitting 500 h. p.
...he dynamo house is 60 feet wide and 200 feet long,
...h heavy walls rising nearly 30 feet, thus giving, aside
...n the basement in which the shafting is located,
...ynamo room 17 feet high to the underside of the truss
... This, like the roof of the engine house, is of wrought
...built by the Berlin Iron Bridge Company. The dyna-
...are on the main floor of the building, just above the
... They are in number 41; 35 of them are Thom-
...Houston arc dynamos with a total capacity of 1,450
...s, of which about 1,300 are in circuit. The incandes-
...department is presided over by five Westinghouse
...ators capable of an aggregate output of 10,500 lamps,
...ich nearly 9,000 are in circuit. The incandescent
...service is entirely by meter. Besides this a 500 volt
...on-Houston generator is operated on a motor circuit
...nning 88 machines with a total capacity of 229 h. p.
...cuits of the company include, all told, 300 miles of
...work that is a model of its kind. This brief sketch
...e a rough idea of the many good points of what is in
...spects a model station. It furnishes the most
...ent exhibit displayed at the present meeting of the
...Electric Light Association.

Efficiency of Transformers.

BY WILLIAM STANLEY, JR.

...owing data, taken from tests made at the Stanley
...y at Pittsfield, may be of interest to engineers.
...ormers are presumably of the latest design, as
...tirely new, and obtained from the manufacturer
...e last thirty days. The method adopted for
...he hysteresis and Foucault losses was the sam
...ven by Blakesley, known as Blakesley's split
...ter method of determining lag, which, while it
...ute and cannot be relied upon for very accurate
...nts, is sufficiently proximate for commercial
...fords a reliable basis of comparison between
...transformers. It is unfortunate that two of
...ners were of larger size than the others, for it
...ely easy to design a 1,200-watt transformer
...efficiency one per cent. greater than a 1,000-
...mer designed with equal care would have
...f the active iron in the transformers tested
...cent. for a given output. It should be borne
...the column marked "maximum efficiency"
...ality lower values than actually are obtained
...ause the total loss in a transformer is not the
...by hysteresis and the C^2R losses, measured
...rmer is doing no work, but is less than the
...es, because the hysteresis loss falls off as the
...l upon the secondary, and generally that
...ot intended for more than comparative
...nsformers tested converted from 1,000 to
...tested, save the Thomson-Houston trans-
...ent was taken from one of the Westing-
...alternators at a frequency of 138 periods
...the case of the Thomson-Houston trans-
...ted with the current from a Thomson
...at 125 periods per second.
...the type and size of transformer; column
...ing through the transformer when the
...n; column 3, the potential on the prim-
...e C^2R loss in primary and secondary
...the percentage drop below normal po-
...dary circuit at full load; column 6, the
...ault losses; column 7, the efficiencies at
...rom columns 4 and 6 together. A sched-
...f the transformers is appended. It is
...hat the watts lost per pound of iron in
...varies from 1.1 watts to .3 watt per
...mentioned, the size of the transform-
...item in estimating its efficiency. The
..."Slattery," 25-light size (1,250 watts),
...fficiency of 94.0 per cent., principally
...per cent. greater capacity, its copper
...ficiently used. Certain transformers
...of 1,500-watt capacity exceed 96 per
...ted on the same basis as those in the

...he efficiency of a transformer is a
..., clearly indicates that the trans-
...ty should be in general use, as it is
...lesign them of 5,000 to 10,000 watts
...y of 97½ per cent., while it is far
...a 250-watt transformer at an effi-

...age	E. M. F.	Total C^2R.	Drop.	Hys.	Max. eff.
...amp.	1,000 volts.	19.25	1.9	37.5	94.3
"	1,000 "	20.8	2.1	48.	93.1
"	1,000 "	30.2	2.	45.5	94.
"	1,000 "	24.3	2.4	75.	90.1
"	1,000 "	27.	1.8	129.3	87.5
"	1,000				

(20-light) 46 pounds (without case.)
(25-light) 121 "
(20-light) 81 "
(25-light) 115 "
(20-light) 83 "

Phenomena of Alternating Currents of Very High Frequency.

BY NIKOLA TESLA.

ALTERNATE CURRENT MACHINES OF HIGH FREQUENCY; CURIOUS EXPERIMENTS WITH GEISSLER TUBES AND LAMPS; AN EXPLODED NOTION; NOISELESS ALTERNATING ARCS; CONSTANT CURRENT AND CONSTANT POTENTIAL; INTERESTING EXPERIMENT WITH A CONDENSER; DA LIEGT DER HASE IM PFEFFER BEGRABEN; THE FERRANTI MAIN EFFECT; SUGGESTIONS OF MR. SWINBURNE.

Electrical journals are getting to be more and more interesting. New facts are observed and new problems spring up daily which command the attention of engineers. In the last few numbers of the English journals, principally in the *Electrician*, there have been several new matters brought up which have attracted more than usual attention. The address of Professor Crookes has revived the interest in his beautiful and skillfully performed experiments, the effect observed on the Ferranti mains has elicited the expressions of opinion of some of the leading English electricians, and Mr. Swinburne has brought out some interesting points in connection with condensers and dynamo excitation.

The writer's own experiences have induced him to venture a few remarks in regard to these and other matters, hoping that they will afford some useful information or suggestion to the reader.

Among his many experiments Professor Crookes shows some performed with tubes devoid of internal electrodes, and from his remarks it must be inferred that the results obtained with these tubes are rather unusual. If this be so, then the writer must regret that Professor Crookes, whose admirable work has been the delight of every investigator, should not have availed himself in his experiments of a properly constructed alternate current machine—namely, one capable of giving, say, 10,000 to 20,000 alternations per second. His researches on this difficult but fascinating subject would then have been even more complete. It is true that when using such a machine in connection with an induction coil the distinctive character of the electrodes—which is desirable, if not essential, in many experiments—is lost, in most cases both the electrodes behaving alike; but, on the other hand, the advantage is gained that the effects may be exalted at will. When using a rotating switch or commutator the rate of change obtainable in the primary current is limited. When the commutator is more rapidly revolved the primary current diminishes, and if the current be increased, the sparking, which cannot be completely overcome by the condenser, impairs considerably the virtue of the apparatus. No such limitations exist when using an alternate current machine, as any desired rate of change may be produced in the primary current. It is thus possible to obtain excessively high electromotive forces in the secondary circuit with a comparatively small primary current; moreover, the perfect regularity in the working of the apparatus may be relied upon.

The writer will incidentally mention that any one who attempts for the first time to construct such a machine will have a tale of woe to tell. He will first start out, as a matter of course, by making an armature with the required number of polar projections. He will then get the satisfaction of having produced an apparatus which is fit to accompany a thoroughly Wagnerian opera. It may besides possess the virtue of converting mechanical energy into heat in a nearly perfect manner. If there is a reversal in the polarity of the projections, he will get heat out of the machine; if there is no reversal, the heating will be less, but the output will be next to nothing. He will then abandon the iron in the armature, and he will get from the Scylla to the Charybdis. He will look for one difficulty and will find another, but, after a few trials, he may get nearly what he wanted.

Among the many experiments which may be performed with such a machine, of not the least interest are those performed with a high-tension induction coil. The character of the discharge is completely changed. The arc is established at much greater distances, and it is so easily affected by the slightest current of air that it often wriggles around in the most singular manner. It usually emits the rhythmical sound peculiar to the alternate current arcs, but the curious point is that the sound may be heard with a number of alternations far above ten thousand per second, which by many is considered to be about the limit of audition. In many respects the coil behaves like a static machine. Points impair considerably the sparking interval, electricity escaping from them freely, and from a wire attached to one of the terminals streams of light issue, as though it were connected to a pole of a powerful Toepler machine. All these phenomena are, of course, mostly due to the enormous differences of potential obtained. As a consequence of the self-induction of the coil and the high frequency, the current is minute while there is a corresponding rise of pressure. A current impulse of some strength started in such a coil should persist to flow no less than four ten-thousandths of a second. As this time is greater than half the period it occurs that an opposing electromotive force begins to act while the current is still flowing. As a consequence, the pressure rises as in a tube filled with liquid and vibrated rapidly around its axis. The current is so small that, in the opinion and involuntary experience of the writer, the discharge of even a very large coil cannot produce seriously injurious effects, whereas, if the same coil were operated with a current of lower frequency, though the electromotive force would be much smaller, the discharge would be most certainly injurious. This result, however, is due in part to the high frequency. The writer's experiences tend to show that the higher the frequency the greater the amount of electrical energy which may be passed through the body without serious discomfort; whence it seems certain that human tissues act as condensers.

One is not quite prepared for the behavior of the coil when connected to a Leyden jar. One, of course, anticipates that since the frequency is high the capacity of the jar should be small. He therefore takes a very small jar about the size of a small wine-glass, but he finds that even with this jar the coil is practically short-circuited. He then reduces the capacity until he comes to about the capacity of two spheres, say, ten centimetres in diameter and two to four centimetres apart. The discharge then assumes the form of a serrated band exactly like a succession of sparks viewed in a rapidly revolving mirror; the serations, of course, corresponding to the condenser discharges. In this case one may observe a queer phenomenon. The discharge starts at the nearest points, works gradually up, breaks somewhere near the top of the spheres, begins again at the bottom, and so on. This goes on so fast that several serrated bands are seen at once. One may be puzzled for a few minutes, but the explanation is simple enough. The discharge begins at the nearest points, the air is heated and carries the arc upward until it breaks, when it is re-established at the nearest points, etc. Since the current passes easily through a condenser of even small capacity, it will be found quite natural that connecting only one terminal to a body of the some size, no matter how well insulate, impairs considerably the striking distance of the arc.

Experiments with Geissler tubes are of special interest. An exhausted tube, devoid of electrodes of any kind, will light up at some distance from the coil. If a tube from a vacuum pump is near the coil the whole of the pump is brilliantly lighted. An incandescent lamp approached to the coil lights up and gets perceptibly hot. If a lamp have the terminals connected to one of the binding posts of the coil and the hand is approached to the bulb, a very curious and rather unpleasant discharge from the glass to the hand takes place, and the filament may become incandescent. The discharge resembles to some extent the stream issuing from the plates of a powerful Toepler machine, but is of incomparably greater quantity. The lamp in this case acts as a condenser, the rarefied gas being one coating, the operator's hand the other. By taking the globe of a lamp in the hand, and by bringing the metallic terminals near to or in contact with a conductor connected to the coil, the carbon is brought to bright incandescence and the glass is rapidly heated. With a 100-volt 10 c. p. lamp one may without great discomfort stand as much current as will bring the lamp to a considerable brilliancy; but it can be held in the hand only for a few minutes as the glass is heated in an incredibly short time. When a tube is lighted by bringing it near to the coil it may be made to go out by interposing a metal plate or the hand between the coil and tube; but if the metal plate be fastened to a glass rod or otherwise insulated, the tube may remain lighted if the plate be interposed, or may even increase in luminosity. The effect depends on the position of the plate and tube relatively to the coil and may be always easily foretold by *assuming* that conduction takes place from one terminal of the coil to the other. According to the position of the plate, it may either divert from or direct the current to the tube.

In another line of work the writer has in frequent experiments maintained incandescent lamps of 50 or 100 volts burning at any desired candle power with both the terminals of each lamp connected to a stout copper wire of no more than a few feet in length. These experiments seem interesting enough, but they are not more so than the queer experiment of Faraday, which has been revived and made much of by recent investigators, and in which a discharge is made to jump between two points of a bent copper wire. An experiment may be cited here which may seem equally interesting. If a Geissler tube, the terminals of which are joined by a copper wire, be approached to the coil, certainly no one would be prepared to see the tube light up. Curiously enough, it does light up, and, what is more, the wire does not seem to make much difference. Now one is apt to think in the first moment that the impedance of the wire might have something to do with the phenomenon. But this is of course immediately rejected, as for this an enormous frequency would be required. The result, however, seems puzzling only at first; for upon reflection it is quite clear that the wire can make but little difference. It may be explained in more than one way, but it agrees perhaps best with observation to assume that conduction takes place from the terminals of the coil through the space. On this assumption, if the tube with the wire be held in any position, the wire can divert little more than the current which passes through the space occupied by the wire and the metallic terminals of the tube; through the adjacent space the current passes practically undisturbed. For this reason, if the tube be held in any position at right angles to the line joining the binding posts of the coil, the wire makes hardly any difference, but in a position more

or less parallel with that line it im...
the brilliancy of the tube and...
Numerous other phenomena may...
assumption. For instance, if the...
vided with washers of sufficient...
joining the terminals of the c...
as then nearly the whole of th...
otherwise pass uniformly throu...
the washers, is diverted throug...
tube be inclined sufficiently to...
up in spite of the washers. Als...
ened upon a glass rod and held...
joining the binding posts, and ne...
held more or less parallel with...
stantly when one of its termin...
will go out when separated fro...
the surface of the plate up to a...
tube will light up. When a tul...
to the straight line joining the...
tated, its luminosity steadily in...
with that line. The writer m...
does not favor the idea of a leal...
space any more than as a suit...
convinced that all these exper...
formed with a static machine...
ence of potential, and that con...
cerned in these phenomena.
It is well to take certain pr...
Ruhmkorff coil with very r...
The primary current should n...
the core may get so hot as t...
paraffin, or otherwise injure t...
occur in a surprisingly short...
considered. The primary cu...
fine wire terminals may be jo...
impedance being so great that...
current through the fine wi...
fact the coil may be on the w...
minals of the fine wire are co...
insulated; but special care sl...
minals are connected to the co...
anywhere near the critical c...
acts the self-induction at th...
might meet the fate of St. ...
vacuum pump is lighted up...
touched with a wire connect...
current should be left on no...
the glass will be cracked by...
in one of the narrow passag...
rience *quod erat demonstrai*...
There are a good many ot...
may be observed in connect...
periments with the telephor...
or with a condenser or arc...
that sounds far above the u...
would be perceived. A tele...
to thirteen thousand vibrati...
of the core to follow such r...
If, however, the magnet ar...
ser and the terminals conne...
ary of a transformer higher...
current be sent around a fir...
piece of thin sheet iron be...
sound may be still heard v...
sand alternations per secon...
ficiently strong. A small c...
tween the poles of a power...
with the above number c...
audible with still a hi...
audition is variously...
Thomson's writings it...
thousand per second, or...
but less reliable, sourc...
four thousand per sec...
have convinced the v...
parably higher number c...
perceived provided they...
power. There is no reas...
condensations and rarefa...
set the diaphragm in a c...
sensation would be produc...
—the velocity of transmi...
it is probable that for w...
be able to distinguish an...
it is different; if the ser...
sonance effect, as many...
the intensity of the eth...
range of vision on eithe...
The limit of audition c...
greater the surface by a...
higher the limit of audi...
by the high-tension disc...
the arc is, so to speak, a...
of an arc, and C the cu...
n times increased, then...
same current density th...
heating effect is n^3 tim...
n^2 times as great. Fo...

* It is thought necessar...
coil may give quite a goo...
alternating currents, ye...
iron core, makes it...
obtain the be...

or less parallel with that line it impairs to a certain extent the brilliancy of the tube and its facility to light up. Numerous other phenomena may be explained on the same assumption. For instance, if the ends of the tube be provided with washers of sufficient size and held in the line joining the terminals of the coil, it will not light up, as then nearly the whole of the current, which would otherwise pass uniformly through the space between the washers, is diverted through the wire. But if the tube be inclined sufficiently to that line, it will light up in spite of the washers. Also, if a metal plate be fastened upon a glass rod and held at right angles to the line joining the binding posts, and nearer to one of them, a tube held more or less parallel with the line will light up instantly when one of its terminals touches the plate and will go out when separated from the plate. The greater the surface of the plate up to a certain limit, the easier the tube will light up. When a tube is placed at right angles to the straight line joining the binding posts, and then rotated, its luminosity steadily increases until it is parallel with that line. The writer must state, however, that he does not favor the idea of a leakage or current through the space any more than as a suitable explanation, for he is convinced that all these experiments could not be performed with a static machine yielding a constant difference of potential, and that condenser action is largely concerned in these phenomena.

It is well to take certain precautions when operating a Ruhmkorff coil with very rapidly alternating currents. The primary current should not be turned on too long, else the core may get so hot as to melt the gutta-percha or paraffin, or otherwise injure the insulation, and this may occur in a surprisingly short time, the current's strength considered. The primary current being turned on, the fine wire terminals may be joined without great risk, the impedence being so great that it is difficult to force enough current through the fine wire so as to injure it, and in fact the coil may be on the whole much safer when the terminals of the fine wire are connected than when they are insulated; but special care should be taken when the terminals are connected to the coatings of a Leyden jar, for with anywhere near the critical capacity, which just counteracts the self-induction at the existing frequency, the coil might meet the fate of St. Polycarpus. If an expensive vacuum pump is lighted up by being near to the coil or touched with a wire connected to one of the terminals, the current should be left on no more than a few moments, else the glass will be cracked by the heating of the rarefied gas in one of the narrow passages—in the writer's own experience *quod erat demonstrandum.**

There are a good many other points of interest which may be observed in connection with such a machine. Experiments with the telephone, a conductor in a strong field or with a condenser or arc seem to afford certain proof that sounds far above the usual accepted limit of hearing would be perceived. A telephone will emit notes of twelve to thirteen thousand vibrations per second, then the inability of the core to follow such rapid alternations begins to tell. If, however, the magnet and core be replaced by a condenser and the terminals connected to the high-tension secondary of a transformer higher notes may still be heard. If the current be sent around a finely laminated core and a small piece of thin sheet iron be held gently against the core, a sound may be still heard with thirteen to fourteen thousand alternations per second, provided the current is sufficiently strong. A small coil, however, tightly packed between the poles of a powerful magnet, will emit a sound with the above number of alternations, and arcs may be audible with still a higher frequency. The limit of audition is variously estimated. In Sir William Thomson's writings it is stated somewhere that ten thousand per second, or nearly so, is the limit. Other, but less reliable, sources give it as high as twenty four thousand per second. The above experiments have convinced the writer that notes of an incomparably higher number of vibrations per second would be perceived provided they could be produced with sufficient power. There is no reason why it should not be so. The condensations and rarefactions of the air would necessarily set the diaphragm in a corresponding vibration and some sensation would be produced whatever—within certain limits—the velocity of transmission to their nerve centres, though it is probable that for want of exercise the ear would not be able to distinguish any such high note. With the eye it is different: if the sense of vision is based upon some resonance effect, as many believe, no amount of increase in the intensity of the ethereal vibration could extend our range of vision on either side of the visible spectrum.

The limit of audition of an arc depends on its size. The greater the surface by a given heating effect in the arc the higher the limit of audition. The highest notes are emitted by the high-tension discharges of an induction coil in which the arc is, so to speak, all surface. If R be the resistance of an arc, and C the current, and the linear dimensions be n times increased, then the resistance is $\frac{R}{n}$, and with the same current density the current would be n^2C; hence the heating effect is n^3 times greater, while the surface is only n^2 times as great. For this reason very large arcs would not emit any rhythmical sound even with a very low frequency. It must be observed, however, that the sound emitted depends to some extent also on the composition of the carbon. If the carbon contain highly refractory material, this when heated tends to maintain the temperature of the arc uniform and the sound is lessened; for this reason it would seem that an alternating arc requires such carbons.

With currents of such high frequencies it is possible to obtain noiseless arcs, but the regulation of the lamp is rendered extremely difficult on account of the excessively small attractions or repulsions between conductors conveying these currents.

An interesting feature of the arc produced by these rapidly alternating currents is its persistency. There are two causes for it, one of which is always present, the other sometimes only. One is due to the character of the current and the other to a property of the machine. The first cause is the more important one, and is due directly to the rapidity of the alternations. When an arc is formed by a periodically undulating current, there is a corresponding undulation in the temperature of the gaseous column, and, therefore, a corresponding undulation in the resistance of the arc. But the resistance of the arc varies enormously with the temperature of the gaseous column, being practically infinite when the gas between the electrodes is cold. The persistence of the arc, therefore, depends on the inability of the column to cool. It is for this reason impossible to maintain an arc with the current alternating only a few times a second. On the other hand, with a practically continuous current, the arc is easily maintained, the column being constantly kept at a high temperature and low resistance. The higher the frequency the smaller the time interval during which the arc may cool and increase considerably in resistance. With a frequency of 10,000 per second or more in an arc of same size excessively small variations of temperature are superimposed upon a steady temperature, like ripples on the surface of a deep sea. The heating effect is practically continuous and the arc behaves like one produced by a continuous current, with the exception, however, that it may not be quite as easily started, and that the electrodes are equally consumed; though the writer has observed some irregularities in this respect.

The second cause alluded to, which possibly may not be present, is due to the tendency of a machine of such high frequency to maintain a practically constant current. When the arc is lengthened the electromotive force rises in proportion and the arc appears to be more persistent.

Such a machine is eminently adapted to maintain a constant current, but it is very unfit for a constant potential. As a matter of fact, in certain types of such machines a nearly constant current is an almost unavoidable result. As the number of poles or polar projections is greatly increased, the clearance becomes of great importance. One has really to do with a great number of very small machines. Then there is the impedence in the armature, enormously augmented by the high frequency. Then, again, the magnetic leakage is facilitated. If there are three or four hundred alternate poles the leakage is so great that it is virtually the same as connecting, in a two-pole machine, the poles by a piece of iron. This disadvantage, it is true, may be obviated more or less by using a field throughout of the same polarity, but then one encounters difficulties of a different nature. All these things tend to maintain a constant current in the armature circuit.

In this connection it is interesting to notice that even to-day engineers are astonished at the performance of a constant current machine, just as, some years ago, they used to consider it an extraordinary performance if a machine was capable of maintaining a constant potential difference between the terminals. Yet one result is just as easily secured as the other. It must only be remembered that in an inductive apparatus of any kind, if constant potential is required, the inductive relation between the primary or exciting and secondary or armature circuit must be the closest possible; whereas, in an apparatus for constant current just the opposite is required. Furthermore, the opposition to the current's flow in the induced circuit must be as small as possible in the former and as great as possible in the latter case. But opposition to a current's flow may be caused in more than one way. It may be caused by ohmic resistance or self induction. One may make the induced circuit of a dynamo machine or transformer of such high resistance that when operating devices of considerably smaller resistance within very wide limits a nearly constant current is maintained. But such high resistance involves a great loss in power, hence it is not practicable. Not so self-induction. Self-induction does not necessarily mean loss of power. The moral is, use self-induction instead of resistance. There is, however, a circumstance which favors the adoption of this plan, and this is, that a very high self-induction may be obtained cheaply by surrounding a comparatively small length of wire more or less completely with iron, and, furthermore, the effect may be exalted at will by causing a rapid undulation of the current. To sum up, the requirements for constant current are: Weak magnetic connection between the induced and inducing circuits, greatest possible self-induction with the least resistance, greatest practicable rate of change of the current. Constant potential, on the other hand, requires: Closest magnetic connection between the circuits, steady induced current, and, if possible, no reaction. If the latter conditions could be fully satisfied in a constant potential machine, its output would surpass many times that of a machine primarily designed to give constant current. Unfortunately, the type of machine in which these conditions may be satisfied is of little practical value, owing to the small electromotive force obtainable and the difficulties in taking off the current.

With their keen inventor's instinct, the now successful arc-light men have early recognized the desideratums of a constant current machine. Their arc light machines have weak fields, large armatures, with a great length of copper wire and few commutator segments to produce great variations in the current's strength and to bring self-induction into play. Such machines may maintain within considerable limits of variation in the resistance of the circuit a practically constant current. Their output is of course correspondingly diminished, and, perhaps, with the object in view not to cut down the output too much, a simple device compensating exceptional variations is employed. The undulation of the current is almost essential to the commercial success of an arc-light system. It introduces in the circuit a steadying element taking the place of a large ohmic resistance, without involving a great loss in power, and, what is more important, it allows the use of simple clutch lamps, which with a current of a certain number of impulses per second, best suitable for each particular lamp, will, if properly attended to, regulate even better than the finest clock-work lamps. This discovery has been made by the writer—several years too late.

It has been asserted by competent English electricians that in a constant current machine or transformer the regulation is effected by varying the phase of the secondary current. That this view is erroneous may be easily proved by using, instead of lamps, devices each possessing self-induction and capacity or self-induction and resistance—that is, retarding and accelerating components—in such proportions as to not affect materially the phase of the secondary current. Any number of such devices may be inserted or cut out, still it will be found that the regulation occurs, a constant current being maintained while the electromotive force is varied with the number of the devices. The change of phase of the secondary current is simply a result following from the changes in resistance, and, though secondary reaction is always of more or less importance, yet the real cause of the regulation lies in the existence of the conditions above enumerated. It should be stated, however, that in the case of a machine the above remarks are to be restricted to the cases in which the machine is independently excited. If the excitation be effected by commutating the armature current, then the fixed position of the brushes makes any shifting of the neutral line of the utmost importance, and it may not be thought immodest of the writer to mention that, as far as records go he seems to have been the first who has successfully regulated machines in providing a bridge connection between a point of the external circuit and the commutator by means of a third brush. The armature and field being properly proportioned and the brushes placed in their determined positions, a constant current or constant potential resulted from the shifting of the diameter of commutation by the varying loads.

In connection with machines of such high frequencies the condenser affords an especially interesting study. It is easy to raise the electromotive force of such a machine to four or five times the value by simply connecting the condenser to the circuit, and the writer has continually used the condenser for the purposes of regulation as suggested by Blakesley in his book on alternate currents, in which he has treated the most frequently occurring condenser problems with exquisite simplicity and clearness. The high frequency allows the use of small capacities and renders investigation easy. But, although in most of the experiments the result may be foretold, yet some phenomena observed seem at first curious. One experiment performed three or four months ago with such a machine and a condenser may serve as illustration. A machine was used giving about 20,000 alternations per second. Two bare wires of about 20 feet long and two millimetres diameter, in close proximity to each other, were connected to the terminals of the machine on the one end, and to a condenser on the other. A small transformer without an iron core, of course, was used to bring the reading within the range of a Cardew voltmeter by connecting the voltmeter to the secondary. On the terminals of the condenser the electromotive force was about 120 volts, and from there inch by inch it gradually fell until on the terminals of the machine it was about 65 volts. It was virtually as though the condenser were a generator, and the line and armature circuit simply a resistance connected to it. The writer looked for a case of resonance, but he was unable to augment the effect by varying the capacity very carefully and gradually or by changing the speed of the machine. A case of pure resonance he was unable to obtain. When a condenser was connected to the terminals of the machine—the self-induction of the armature being first determined in the maximum and minimum position and the mean value taken—the capacity which gave the highest electromotive force corresponded most nearly to that which just

* It is thought necessary to remark that, although the induction coil may give quite a good result when operated with such rapidly alternating currents, yet its construction, quite irrespective of the iron core, makes it very unfit for such high frequencies, and to obtain the best results the construction should be greatly modified.

counteracted the self-induction with the existing frequency. If the capacity was increased or diminished the electromotive force fell as expected.

With frequencies as high as the above mentioned the condenser effects are of enormous importance. The condenser becomes a highly efficient apparatus capable of transferring considerable energy.

The writer has thought that machines of high frequencies may find use at least in cases when transmission at great distances is not contemplated. The increase of the resistance may be reduced in the conductors and exalted in the devices when heating effects are wanted, transformers may be made of higher efficiency and greater outputs and valuable results may be secured by means of condensers. In using machines of high frequency the writer has been able to observe condenser effects which would have otherwise escaped his notice. He has been very much interested in the phenomenon observed on the Ferranti main which has been so much spoken of. Opinions have been expressed by competent electricians, but up to the present all still seems to be conjecture. Undoubtedly in the views expressed the truth must be contained, but as the opinions differ some must be erroneous. Upon seeing the diagram of M. Ferranti in the *Electrician* of Dec. 19 the writer has formed his opinion of the effect. In the absence of all the necessary data he must content himself to express in words the process which, in his opinion, must undoubtedly occur. The condenser brings about two effects: (1) It changes the phases of the currents in the branches; (2) it changes the strength of the currents. As regards the change in phase, the effect of the condenser is to accelerate the current in the secondary at Deptford and to retard it in the primary at London. The former has the effect diminishing the self-induction in the Deptford primary, and this means lower electromotive force on the dynamo. The retardation of the primary at London, as far as merely the phase is concerned, has little or no effect since the phase of the current in the secondary in London, is not arbitrarily kept.

Now, the second effect of the condenser is to increase the current in both the branches. It is immaterial whether there is equality between the currents or not; but it is necessary to point out, in order to see the importance of the Deptford step-up transformer, that an increase of the current in both the branches produces opposite effects. At Deptford it means further lowering of the electromotive force at the primary, and at London it means increase of the electromotive force at the secondary. Therefore, all the things co-act to bring about the phenomenon observed. Such actions, at least, have been formed to take place under similar conditions. When the dynamo is connected directly to the main, one can see that no such action can happen.

The writer has been particularly interested in the suggestions and views expressed by Mr. Swinburne. Mr. Swinburne has frequently honored him by disagreeing with his views. Three years ago, when the writer, against the prevailing opinion of engineers, advanced an open circuit transformer, Mr. Swinburne was the first to condemn it by stating in the *Electrician*: "The (Tesla) transformer must be inefficient; it has magnetic poles revolving, and has thus an *open* magnetic circuit." Two years later Mr. Swinburne becomes the champion of the open circuit transformer, and offers to convert him. But, *tempora mutantur et nos mutamur in illis.*

The writer cannot believe in the armature reaction theory as expressed in *Industries*, though undoubtedly there is some truth in it. Mr. Swinburne's interpretation, however, is so broad that it may mean anything.

Mr. Swinburne seems to have been the first who has called attention to the heating of the condensers. The astonishment expressed at that by the ablest electrician is a striking illustration of the desirability to execute experiments on a large scale. To the scientific investigator, who deals with the minutest quantities, who observes the faintest effects, far more credit is due than to one who experiments with apparatus on an industrial scale; and indeed history of science has recorded examples of marvelous skill, patience and keenness of observation. But however great the skill, and however keen the observer's perception, it can only be of advantage to magnify an effect and thus facilitate its study. Had Faraday carried out but one of his experiments on dynamic induction on a large scale it would have resulted in an incalculable benefit.

In the opinion of the writer, the heating of the condensers is due to three distinct causes: first, leakage or conduction; second, imperfect elasticity in the dielectric, and, third, surging of the charges in the conductor.

In many experiments he has been confronted with the problem of transferring the greatest possible amount of energy across a dielectric. For instance, he has made incandescent lamps the ends of the filaments being completely sealed in glass, but attached io interior condenser coatings so that all the energy required had to be transferred across the glass with a condenser surface of no more than a few centimetres square. Such lamps would be a practical success with sufficiently high frequencies. With alternations as high as 15,000 per second it was easy to bring the filaments to incandescence. With lower frequencies this could also be effected, but the potential difference had, of course, to be increased. The writer has then found that the glass gets, after a while, perforated and the vacuum is impaired. The higher the frequency the longer the lamp can withstand. Such a deterioration of the dielectric always takes place when the amount of energy transferred across a dielectric of definite dimensions and by a given frequency is too great. Glass withstands best, but even glass is deteriorated. In this case the potential difference on the plates is of course too great and losses by conduction and imperfect elasticity result. If it is desirable to produce condensers capable to stand great differences of potential, then the only dielectric which will involve no losses is a gas under pressure. The writer has worked with air under enormous pressures, but there are great many practical difficulties in that direction. He thinks that, in order to make the condensers of considerable practical utility, higher frequencies should be used; though such a plan has besides others the great disadvantage that the system would become very unfit for the operation of motors.

If the writer does not err, Mr. Swinburne has suggested a way of exciting an alternator by means of a condenser. For a number of years past the writer has carried on experiments with the object in view of producing a practical self-exciting alternator. He has in a variety of ways succeeded in producing some excitation of the magnets by means of alternating currents, which were not commutated by mechanical devices. Nevertheless, his experiments have revealed a fact which stands as solid as the rock of Gibraltar. No practical excitation can be obtained with a single periodically varying and not commutated current. The reason is that the changes in the strength of the exciting current produce corresponding changes in the field strength, with the result of inducing currents in the armature; and these currents interfere with those produced by the motion of the armature through the field, the former being a quarter phase in advance of the latter. If the field be laminated, no excitation can be produced; if it be not laminated, some excitation is produced, but the magnets are heated. By combining two exciting currents displaced by a quarter phase, excitation may be produced in both cases, and if the magnet be not laminated the heating effect is comparatively small, as a uniformity in the field strength is maintained, and, were it possible to produce a perfectly uniform field, excitation on this plan would give quite practical results. If such results are to be secured by the use of a condenser, as suggested by Mr. Swinburne, it is necessary to combine two circuits separated by a quarter phase; that is to say, the armature coils must be wound in two sets and connected to one or two independent condensers. The writer has done some work in that direction, but must defer the description of the devices for some future time.

The Dimensions of Crocker-Wheeler Motors.

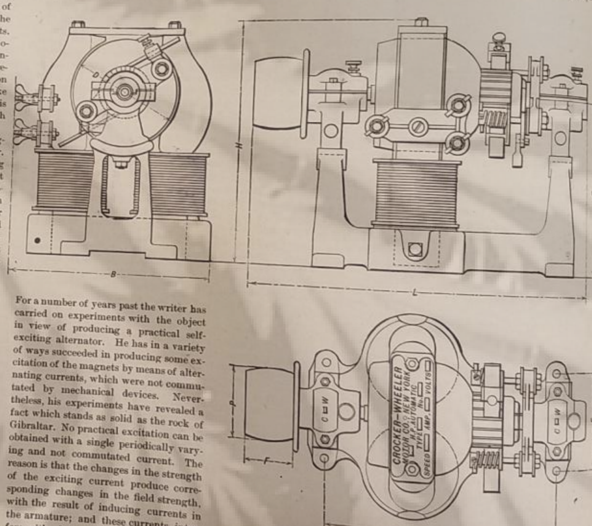
The space occupied by the electric motor is so much less than that required for a stationary engine of the same capacity that a great advantage is gained in favor of the motor in all locations where space is a matter of importance. As a means of comparing dimensions of the engines which any of our readers may have in use with

TABLE OF DIMENSIONS AND OTHER DATA OF THE CROCKER-WHEELER MOTORS.

Horse power.	Net weight, lbs.	Speed.	Pulley. "P." Diameter, ins.	Pulley. "F." Face, ins.	Size of motor over all. "L." Length, ins.	Size of motor over all. "B." Breadth, ins.	Size of motor over all. "H." Height, ins.	"G." Length between bolt holes in base.	"E." Breadth between bolt holes in base.	Diam. Shaft, ins.	"D." Diam. Armature, ins.	Height of shaft center from base of motor
[illegible]	18	2,100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
¼	26	2,000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	26	1,800	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	65	1,500	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	100	1,350	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1	137	1,650	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	200	1,050	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	300	1,000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	485	1,000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

* Grooved. † Flat.
NOTE.—The standard incandescent motors are wound for 110, 220 and 500 volts. Each motor is tested, and the speed and voltage stamped on before shipment; but should the voltage of the circuit vary from the standard, there will be a corresponding difference in the speed of the motor. Arc motors are wound for 6.5, 9.5 and 18 amperes.

of one of the standard types of electric motors, the table of dimensions and other data and the diagrammatic view of the Crocker-Wheeler motors are given on this page. By reference to the table and cut it will be seen that the outside dimensions of a motor of any given capacity are readily obtainable. The floor space and weight per horse-power will always be found to be very much in favor of the electric motor as against the engine and boiler, or even the engine alone. It must, however, be remembered that in many installations the motor can be made to occupy space that is otherwise of little or no value, as in cases where it may be attached to the ceiling in an inverted position or placed upon a suitable bracket against the wall.



DIMENSIONS OF CROCKER-WHEELER MOTORS.

Electric Lighting in the Elgin Watch Factory.

The adaptability of the incandescent electric light to purposes requiring a soft, brilliant, and easily controlled light has long since been demonstrated, and in manufacturing establishments producing goods of a delicate and complex nature it has been found absolutely indispensable in obtaining good work from employés. This has very often been appreciated, but never in a greater degree than by the Elgin National Watch Company, at Elgin, Ill. This company authorized the installation of an electric lighting plant, which has, in the fourteen months of its existence, assumed proportions which entitle it to be classed among the largest and finest of its kind in Illinois.

T.C.M.

counteracted the self-induction with the existing frequency. If the capacity was increased or diminished the electromotive force fell as expected.

With frequencies as high as the above mentioned the condenser effects are of enormous importance. The condenser becomes a highly efficient apparatus capable of transferring considerable energy.

The writer has thought that machines of high frequencies may find use at least in cases when transmission at great distances is not contemplated. The increase of the resistance may be reduced in the conductors and exalted in the devices when heating effects are wanted, transformers may be made of higher efficiency and greater outputs and valuable results may be secured by means of condensers. In using machines of high frequency the writer has been able to observe condenser effects which would have otherwise escaped his notice. He has been very much interested in the phenomenon observed on the Ferranti main which has been so much spoken of. Opinions have been expressed by competent electricians, but up to the present all still seems to be conjecture. Undoubtedly in the views expressed the truth must be contained, but as the opinions differ some must be erroneous. Upon seeing the diagram of M. Ferranti in the *Electrician* of Dec. 19 the writer has formed his opinion of the effect. In the absence of all the necessary data he must content himself to express in words the process which, in his opinion, must undoubtedly occur. The condenser brings about two effects: (1) It changes the phases of the currents in the branches; (2) it changes the strength of the currents. As regards the change in phase, the effect of the condenser is to accelerate the current in the secondary at Deptford and to retard it in the primary at London. The former has the effect diminishing the self-induction in the Deptford primary, and this means lower electromotive force on the dynamo. The retardation of the primary at London, as far as merely the phase is concerned, has little or no effect since the phase of the current in the secondary in London, is not arbitrarily kept.

Now, the second effect of the condenser is to increase the current in both the branches. It is immaterial whether there is equality between the currents or not; but it is necessary to point out, in order to see the importance of the Deptford step-up transformer, that an increase of the current in both the branches produces opposite effects. At Deptford it means further lowering of the electromotive force at the primary, and at London it means increase of the electromotive force at the secondary. Therefore, all the things co-act to bring about the phenomenon observed. Such actions, at least, have been formed to take place under similar conditions. When the dynamo is connected directly to the main, one can see that no such action can happen.

The writer has been particularly interested in the suggestions and views expressed by Mr. Swinburne. Mr. Swinburne has frequently honored him by disagreeing with his views. Three years ago, when the writer, against the prevailing opinion of engineers, advanced an open circuit transformer, Mr. Swinburne was the first to condemn it by stating in the *Electrician*: "The (Tesla) transformer must be inefficient; it has magnetic poles revolving, and has thus an *open* magnetic circuit." Two years later Mr. Swinburne becomes the champion of the open circuit transformer, and offers to convert him. But, *tempora mutantur et nos mutamur in illis.*

The writer cannot believe in the armature reaction theory as expressed in *Industries*, though undoubtedly there is

withstand. Such a deterioration of the deelectric always takes place when the amount of energy transferred across a dielectric of definite dimensions and by a given frequency is too great. Glass withstands best, but even glass is deteriorated. In this case the potential difference on the plates is of course too great and losses by conduction and imperfect elasticity result. If it is desirable to produce condensers capable to stand great differences of potential, then

The Dimensions of Crocker-Wheeler Motors.

The space occupied by the electric motor is so much less than that required for a stationary engine of the same capacity that a great advantage is gained in favor of the motor in all locations where space is a matter of importance. As a means of comparing dimensions of steam engines which any of our readers may have in use with

TABLE OF DIMENSIONS AND OTHER DATA OF THE CROCKER-WHEELER MOTORS.

Horse power.	Net weight, lbs.	Speed.	Pulley. "P." Diameter, ins.	Pulley. "F." Face, ins.	Size of motor over all. "L." Length ins.	Size of motor over all. "B." Breadth, ins.	Size of motor over all. "H." Height ins.	"G." Length between bolt holes in base.	"E." Breadth between bolt holes in base.	Diam. Shaft, ins.	"D." Diam. Armature ins.	"C." Height of shaft center from base of motor
[illegible]	18	2,100	1¼* 1¼†	⅝ 1	7⅝	5⅛	7¾	4⅝	2¾	¼	3⅜	[illegible]
1/6	26	2,000	1½* 1½†	⅝ 1	9¾	7½	8½	6⅝	3⅜	⅜	[illegible]	[illegible]
[illegible]	26	1,800	2⅜	1¼	9¾	7½	8½	6⅝	3⅜	⅜	[illegible]	[illegible]
1/4	65	1,500	3	2	14¾	9½	10¾	9¾	[illegible]	[illegible]	4⅞	[illegible]
1/2	100	1,350	3½	3	18¼	11	13	11⅛	5⅝	[illegible]	5⅞	[illegible]
1	157	1,050	4	3½	19	13¼	15⅛	12¼	7	⅞	[illegible]	[illegible]
2	290	1,050	6	3	25	15⅝	18⅜	18¼	9¼	1	8¼	[illegible]
3	300	1,000	6	4	26¼	15⅝	18⅜	18¼	9¼	1	8¼	[illegible]
5	485	1,000	7½	4½	28	18¾	21	18¾	9¾	1⅛	9¾	[illegible]

*Grooved. †Flat.

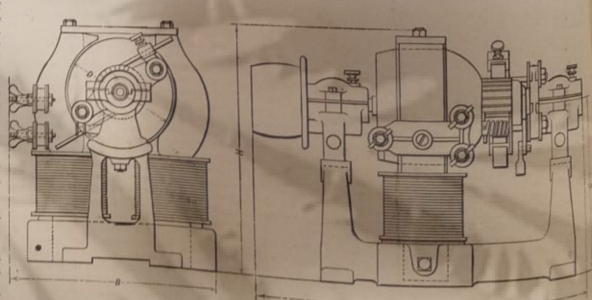
NOTE.—The standard incandescent motors are wound for 110, 220 and 500 volts. Each motor is tested, and the speed and voltage stamped on before shipment; but should the voltage of the circuit vary from the standard, there will be a corresponding difference in the speed of the motor. Arc motors are wound for 6.5, 9.5 and 18 ampères.

the only dielectric which will involve no losses is a gas under pressure. The writer has worked with air under enormous pressures, but there a are great many practical difficulties in that direction. He thinks that, in order to make the condensers of considerable practical utility, higher frequencies should be used; though such a plan has besides others the great disadvantage that the system would become very unfit for the operation of motors.

If the writer does not err, Mr. Swinburne has suggested a way of exciting an alternator by means of a condenser.

For a number of years past the writer has

of one of the standard types of electric motors, the table of dimensions and other data and the diagramatic view of the Crocker-Wheeler motors are given on this page. By reference to the table and cut it will be seen that the outside dimensions of a motor of any given capacity are readily obtainable. The floor space and weight per horse-power will always be found to be very much in favor of the electric motor as against the engine and boiler, or even the engine alone. It must, however, be remembered that in many installations the motor can be made to occupy space



Now, the second effect of the condenser is to increase the current in both the branches. It is immaterial whether there is equality between the currents or not; but it is necessary to point out, in order to see the importance of the Deptford step-up transformer, that an increase of the current in both the branches produces opposite effects. At Deptford it means further lowering of the electromotive force at the primary, and at London it means increase of the electromotive force at the secondary. Therefore, all the things co-act to bring about the phenomenon observed. Such actions, at least, have been formed to take place under similar conditions. When the dynamo is connected directly to the main, one can see that no such action can happen.

The writer has been particularly interested in the suggestions and views expressed by Mr. Swinburne. Mr. Swinburne has frequently honored him by disagreeing with his views. Three years ago, when the writer, against the prevailing opinion of engineers, advanced an open circuit transformer, Mr. Swinburne was the first to condemn it by stating in the *Electrician*: "The (Tesla) transformer must be inefficient; it has magnetic poles revolving, and has thus an *open* magnetic circuit." Two years later Mr. Swinburne becomes the champion of the open circuit transformer, and offers to convert him. But, *tempora mutantur et nos mutamur in illis.*

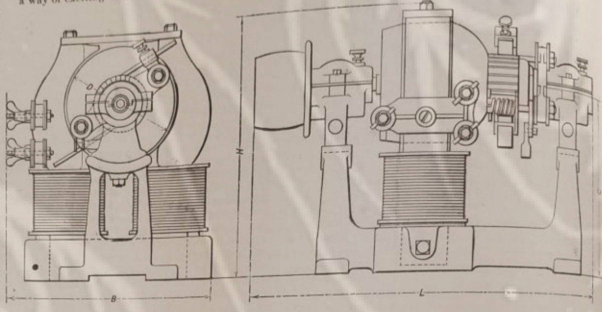
The writer cannot believe in the armature reaction theory as expressed in *Industries*, though undoubtedly there is some truth in it. Mr. Swinburne's interpretation, however, is so broad that it may mean anything.

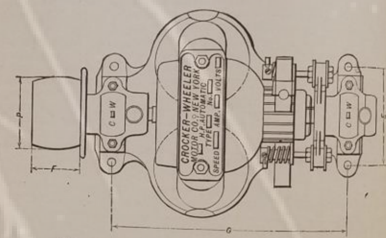
Mr. Swinburne seems to have been the first who has called attention to the heating of the condensers. The astonishment expressed at that by the ablest electrician is a striking illustration of the desirability to execute experiments on a large scale. To the scientific investigator, who deals with the minutest quantities, who observes the faintest effects, far more credit is due than to one who experiments with apparatus on an industrial scale; and indeed history of science has recorded examples of marvelous skill, patience and keenness of observation. But however great the skill, and however keen the observer's perception, it can only be of advantage to magnify an effect and thus facilitate its study. Had Faraday carried out but one of his experiments on dynamic induction on a large scale it would have resulted in an incalculable benefit.

In the opinion of the writer, the heating of the condensers is due to three distinct causes: first, leakage or conduction; second, imperfect elasticity in the dielectric, and, third, surging of the charges in the conductor.

In many experiments he has been confronted with the problem of transferring the greatest possible amount of energy across a dielectric. For instance, he has made incandescent lamps the ends of the filaments being completely sealed in glass, but attached io interior condenser coatings so that all the energy required had to be transferred across the glass with a condenser surface of no more than a few centimetres square. Such lamps would be a practical success with sufficiently high frequencies. With alternations as high as 15,000 per second it was easy to bring the filaments to incandescence. With lower frequencies this could also be effected, but the potential difference had, of course, to be increased. The writer has then found that the glass gets, after a while, perforated and the vacuum is impaired. The higher the frequency the longer the lamp can

If the writer does not err, Mr. Swin[burne] ... a way of exciting an alternator by means of a condenser.





DIMENSIONS OF CROCKER-WHEELER MOTORS.

For a number of years past the writer has carried on experiments with the object in view of producing a practical self-exciting alternator. He has in a variety of ways succeeded in producing some excitation of the magnets by means of alternating currents, which were not commutated by mechanical devices. Nevertheless, his experiments have revealed a fact which stands as solid as the rock of Gibraltar. No practical excitation can be obtained with a single periodically varying and not commutated current. The reason is that the changes in the strength of the exciting current produce corresponding changes in the field strength, with the result of inducing currents in the armature; and these currents interfere with those produced by the motion of the armature through the field, the former being a quarter phase in advance of the latter. If the field be laminated, no excitation can be produced; if it be not laminated, some excitation is produced, but the magnets are heated. By combining two exciting currents displaced by a quarter phase, excitation may be produced in both cases, and if the magnet be not laminated the heating effect is comparatively small, as a uniformity in the field strength is maintained, and, were it possible to produce a perfectly uniform field, excitation on this plan would give quite practical results. If such results are to be secured by the use of a condenser, as suggested by Mr. Swinburne, it is necessary to combine two circuits separated by a quarter phase; that is to say, the armature coils must be wound in two sets and connected to one or two independent condensers. The writer has done some work in that direction, but must defer the description of the devices for some future time.

that is otherwise of little or no value, as in cases where it may be attached to the ceiling in an inverted position or placed upon a suitable bracket against the wall.

Electric Lighting in the Elgin Watch Factory.

The adaptability of the incandescent electric light to purposes requiring a soft, brilliant, and easily controlled light has long since been demonstrated, and in manufacturing estabiishments producing goods of a delicate and complex nature it has been found absolutely indispensable in obtaining good work from employés. This has very often been appreciated, but never in a greater degree than by the Elgin National Watch Company, at Elgin, Ill. This company authorized the installation of an electric lighting plant, which has, in the fourteen months of its existence, assumed proportions which entitle it to be classed among the largest and finest of its kind in Illinois.

4. That the resistance offered to an unvarying electric current by a column of mercury of a constant cross sectional area of one square millimetre, and of a length of 106.3 centimetres at the temperature of melting ice, may be adopted as one ohm.

5. That the value of the standard of resistance constructed by a committee of the British Association for the Advancement of Science in the years 1863 and 1864, and known as the British Association unit, may be taken as .9866 of the ohm.

6. That a material standard constructed in solid metal, and verified by comparison with the British Association unit should be adopted as the Board of Trade standard ohm.

7. That for the purpose of replacing the standard, if lost, destroyed or damaged, and for ordinary use, one or more copies should be constructed, which should be periodically compared with the standard ohm and with the British Association unit.

8. That the standard of electrical current should be denominated the ampère, and should have the value one-tenth (0.1) in terms of the centimetre, gramme and second.

9. That an unvarying current which, when passed through a solution of nitrate of silver and water containing from 15 to 20 parts by weight of nitrate of silver in 100 parts of water, deposits silver at the rate of 0.001118 of a gramme per second, may be taken as a current of one ampère.

10. An alternating current of one ampère shall mean a current such that the square root of the time average of the square of its strength at each instant, in ampères, is unity.

11. That an instrument constructed on the principle of the balance, in which by the proper disposition of the conductors forces of attraction and repulsion are produced, which depend upon the amount of current passing, and are balanced by a known weight, should be adopted as the Board of Trade standard for the measurement of one ampère, whether the current be unvarying or alternating.

12. That the standard of electrical pressure should be denominated the volt, being the pressure which, if steadily applied to a conductor whose resistance is one ohm, will produce a current of one ampère.

13. That the electrical pressure at a temperature of 62 degrees F. between the poles or electrodes of the voltaic cell, known as Clark's cell, constructed and used in accordance with the specification attached to these proceedings, may be taken as not differing by more than .... parts in one thousand from a pressure of........... volts.

An Unique Mining Plant.

Far up among the mountains of Southwestern Colorado lies the little mining town of Telluride. It is one of the oldest mining camps in Colorado, but in these days of mining on a large scale it has not come into prominence until very recently, for the gold lies high up among the hills, thousands of feet above the San Miguel Valley. The ore, although abundant, is not of high grade, and the cost of mining and milling has heretofore been so great as to almost prohibit successful operation. The Gold King Milling and Mining Company, that owns this group of mines, has been in operation for several years, but never with profit until recently. About a year ago Mr. L. L. Nunn, of Telluride, took the general management of the mines, and has made them pay by careful business policy, and the more important fact that he realizes that the only way of operating a low-grade mine is to do it on a very large scale. Until this spring the Gold King Company used a 40 stamp amalgam mill, which with several large ore crushers was operated by a 60 h. p. engine. But during the few years of its operations the needs of the mill, which is above the timber line, had so greatly reduced the available fuel that formerly grew in abundance a few hundred feet below, that the question of motive power had grown to be a very serious one. On consideration it seemed absolutely necessary that some system of electrical transmission of power should be employed, so that one of the great water powers in the immediate neighborhood could operate the mills.

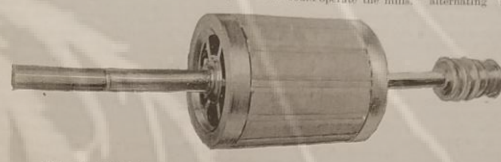


FIG. 2.—ARMATURE OF WESTINGHOUSE MOTOR AND GENERATOR.

The Gold King Mill is at an elevation of 11,000 feet above the sea, and 3,000 feet above the San Miguel Valley. The south fork of the San Miguel River in its descent from Ophir, a mining camp near Telluride, falls 500 feet in a distance of less than a mile. The river is fed almost entirely from springs in the Ophir basin, and even at the season of lowest supply can furnish about 2,000 h. p. Here was available power enough to operate every mine in the vicinity, and on taking up the question of electricity the scene was looked over by various engineers, and finally the Gold King Company closed a contract with the Westinghouse Electric & Manufacturing Company to supply the necessary machinery. A dam has been erected at what is an almost perfect natural site above the beginning of the rapid descent of the stream, and from the headgate the water is conducted through an iron pipe 4,000 feet long, at the beginning some 20 inches in diameter, and then gradually decreasing to 12, along the valley to the power station. Here the stream is divided, and the water is delivered to two six-foot Pelton water wheels in the generating station itself. The ultimate capacity of 800 h.p. in the generators is provided for, although at present only a single 100 h. p. machine will be installed. The motor station is two and a half miles from the generators. It was determined to employ in this large plant synchronous alternating motors, for the reason that the potentials required would be higher than are usually reached in practice by direct current motors, and the method of governing the motors rendered it possible, conveniently, to operate the motors at all sorts of potentials from the same circuit if it should be found desirable. The generator employed is of the same type as the Westinghouse self-exciting incandescent machine with toothed armature. Motor and generator are alike, except in some minor details, and the machines are well shown in Fig. 1. The armature (Fig. 2) is seen to possess the ordinary Westinghouse arrangement of teeth, and has otherwise no striking peculiarities. It was determined to use an electromotive force of 3,000 volts, and the machines are accordingly wound for this potential. The conducting circuit is a No. 8 B. & S. gauge, bare copper wire, erected on stout poles at a sufficient distance above the ground to prevent anything but the remotest possibility of accident. The loss in transmission is barely 5 per cent. The motor being of the synchronizing type, the question of starting it very naturally arises. This has always been the most serious difficulty with alternating currents for the transmission of power. In this case the solution was easy, for while used for the purposes designed the motor does not have to be started at all frequently. Once in step with the generator it may run for many hours without being stopped for any reason whatever. The starting device employed is a two-wire alternating motor of the Tesla form of construction of about 10 h. p. capacity; this machine is shown in Fig. 3. It is used simply and solely for bringing the large motor up to synchronism, when it is cut out until again required. The large motor is self-exciting, and takes care of itself easily enough after it is once brought up to speed. This Telluride plant promises to be, when it shall finally be put into operation a few weeks hence, one of the most interesting mining plants in the world from the nature of its location, which made electrical power a necessity, and especially from the daring way in which the difficulty of using very high potential has been met by employing a synchronizing motor. It is altogether probable that other mines in the vicinity will shortly receive a similar equipment, as the region is one where fuel is none too easily obtained, and water power can be had almost for the asking. The plant is now rapidly nearing completion, and ere long we may hope to chronicle the starting of an installation that is unique in the electrical transmission of power among motor plants, and that has every reason to meet with most gratifying success.

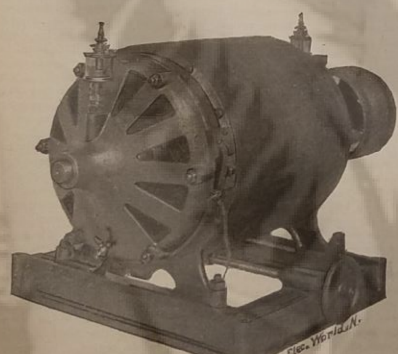


FIG. 3.—TESLA MOTOR USED IN THE TELLURIDE PLANT.

FIG. 1.—MOTOR AND GENERATOR OF THE TELLURIDE MINING PLANT.

Phenomena of Alternating Currents of Very High Frequency.

BY NIKOLA TESLA.

In the issue of THE ELECTRICAL WORLD of March 14 I find a note of Prof. Elihu Thomson relating to some of my experiments with alternating currents of very high frequency which have been described in THE ELECTRICAL WORLD of Feb. 21, 1891.

Prof. Thomson calls attention to the interesting fact that he has performed some experiments in the same line. I was not quite unprepared to hear this, as a letter from him appeared in *The Electrician* (London) a few months ago in which he mentioned a small alternate current machine which was capable of giving, I believe, 5,000 alternations per second, from which letter it likewise appears that his investigations on that subject are of a more recent date.

Prof. Thomson describes an experiment with a bulb inclosing a carbon filament which was brought to incandescence by the bombardment of the molecules of the residual gas when the bulb was immersed in water rendered slightly conducting by salt dissolved therein (?) and a potential of 1,000 volts, alternating 5,000 times a second, applied to the carbon strip. Similar experiments have, of course, been performed by many experimenters, the only distinctive feature in Prof. Thomson's experiment being the comparatively high rate of alternation. These experiments can also

père, whether the current be unvarying or alternating.

12. That the standard of electrical pressure should be denominated the volt, being the pressure which, if steadily applied to a conductor whose resistance is one ohm, will produce a current of one ampère.

13. That the electrical pressure at a temperature of 62 degrees F. between the poles or electrodes of the voltaic cell, known as Clark's cell, constructed and used in accor-

gradually decreasing to station. Here the strea ered to two six-foot Pelton water wheels in the generating station itself. The ultimate capacity of 800 h.p. in

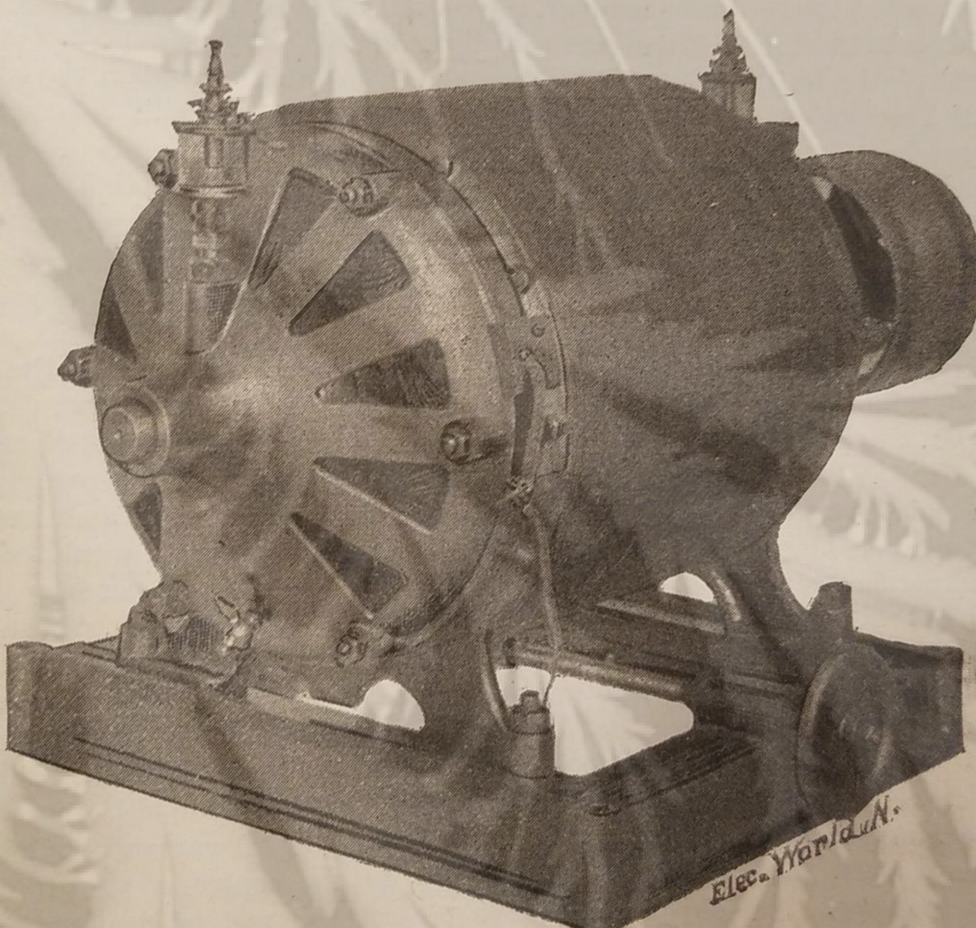


FIG. 3.—TESLA MOTOR USED IN THE TELLURIDE PLANT.

dance with the specification attached to these proceedings, may be taken as not differing by more than .... parts in one thousand from a pressure of........... volts.

An Unique Mining Plant.

the generators is provide single 100 h. p. m motor station is tw the generators. It was plant synchronous altern the potentials required w

turing Company to supply the dam has been erected at what is l site above the beginning of the eam, and from the headgate the h an iron pipe 4,000 feet long, 20 inches in diameter, and then , along the valley to the power is divided, and the water is deliv-

Phenomena of Alternating Currents of Very High Frequency.

BY NIKOLA TESLA.

In the issue of THE ELECTRICAL WORLD of March 14 I find a note of Prof. Elihu Thomson relating to some of my

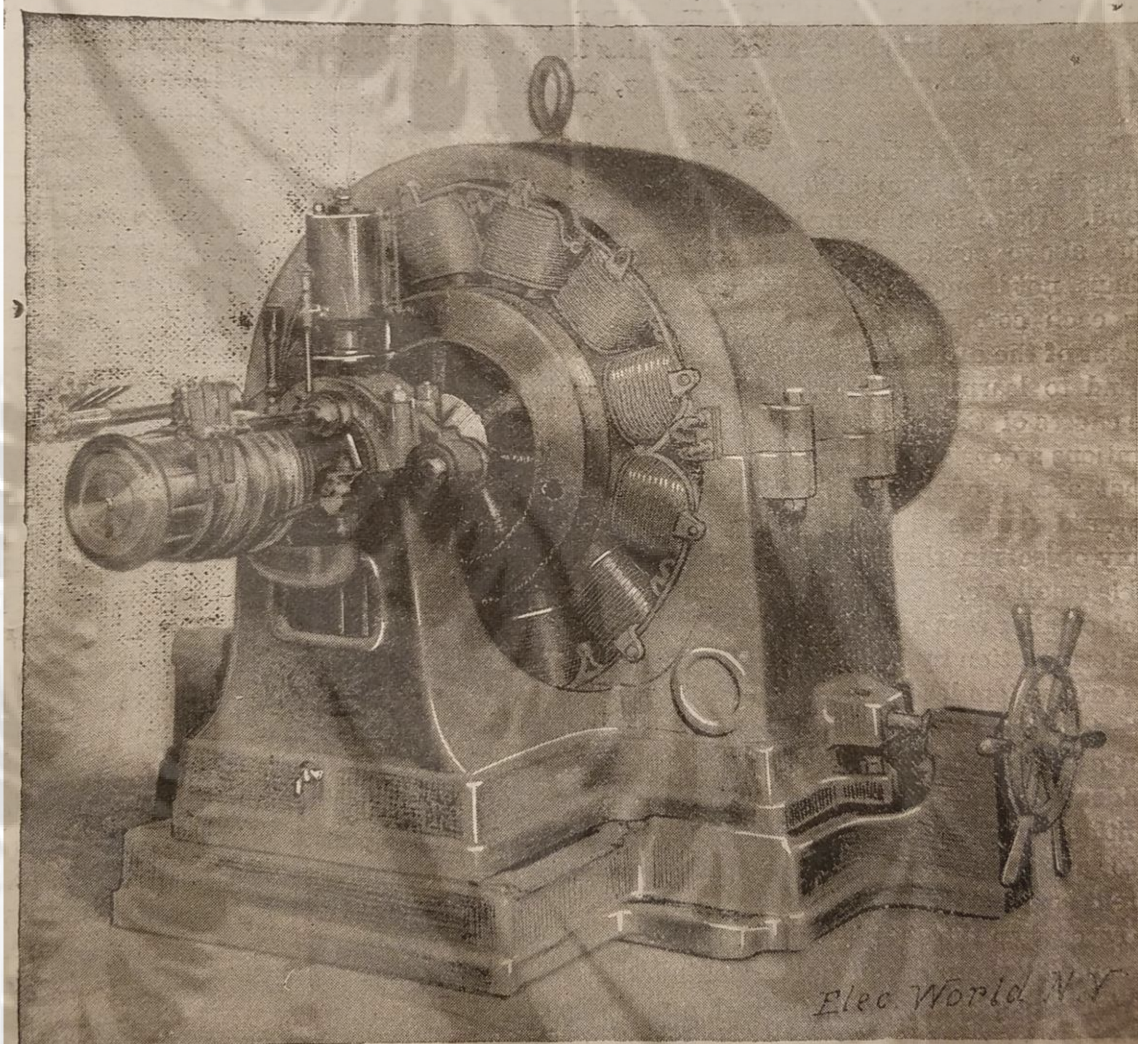


FIG. 1.—MOTOR AND GENERATOR OF THE TELLURIDE MINING PLANT.

for, although at present only a hine will be installed. The

experiments with alternating currents of very high frequency which have been described in THE ELECTRICAL

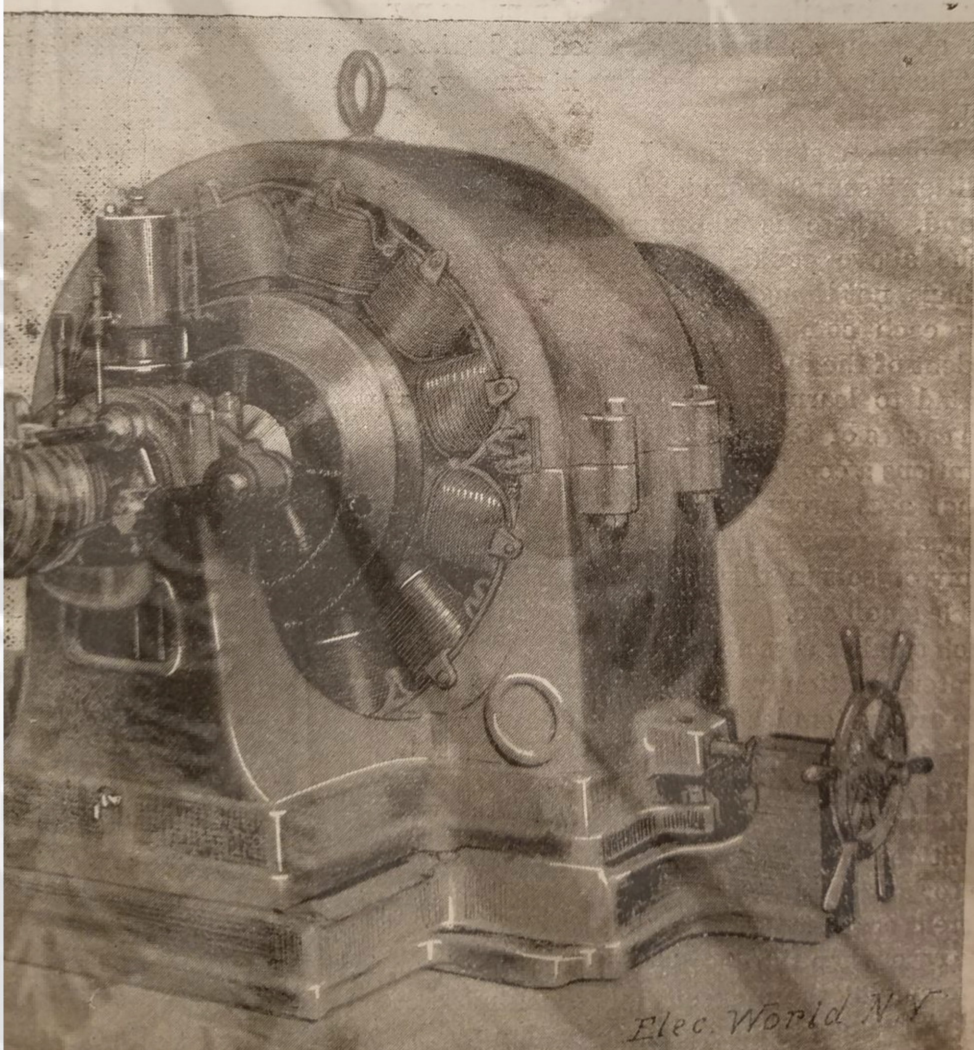
2,000 h. p. Here
ery mine in the
f electricity the
s, and finally the
th the Westing-
y to supply the
rected at what is
beginning of the
the headgate the
4,000 feet long,
ameter, and then
y to the power
he water is deliv-

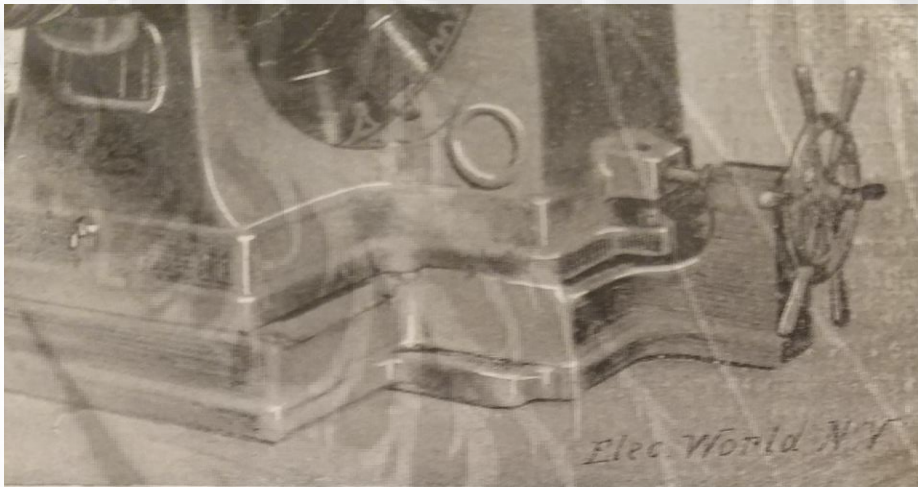
too easily obtained, and water power can be had almost for the asking. The plant is now rapidly nearing completion, and ere long we may hope to chronicle the starting of an installation that is unique in the electrical transmission of power among motor plants, and that has every reason to meet with most gratifying success.

Phenomena of Alternating Currents of Very High Frequency.

BY NIKOLA TESLA.

In the issue of THE ELECTRICAL WORLD of March 14 I find a note of Prof. Elihu Thomson relating to some of my





DR AND GENERATOR OF THE TELLURIDE MINING PLANT.

present only a
stalled. The
miles from
y in this large
e reason that
n are usually
tors, and the
possible, con-
of potentials
esirable. The
the Westing-
with toothed
cept in some
wn in Fig. 1.
dinary West-
wise no strik-
e an electro-
s are accord-
cting circuit
, erected on
the ground
possibility of

experiments with alternating currents of very high frequency which have been described in THE ELECTRICAL WORLD of Feb. 21, 1891.

Prof. Thomson calls attention to the interesting fact that he has performed some experiments in the same line. I was not quite unprepared to hear this, as a letter from him appeared in *The Electrician* (London) a few months ago in which he mentioned a small alternate current machine which was capable of giving, I believe, 5,000 alternations per second, from which letter it likewise appears that his investigations on that subject are of a more recent date.

Prof. Thomson describes an experiment with a bulb inclosing a carbon filament which was brought to incandescence by the bombardment of the molecules of the residual gas when the bulb was immersed in water rendered slightly conducting by salt dissolved therein (?) and a potential of 1,000 volts, alternating 5,000 times a second, applied to the carbon strip. Similar experiments have, of course, been performed by many experimenters, the only distinctive feature in Prof. Thomson's experiment being the comparatively high rate of alternation. These experiments can also

be performed with a steady difference of potential between the water and the carbon strip, in which case, of course, conduction through the glass takes place, the difference of potential required being in proportion to the thickness of the glass. With 5,000 alternations per second conduction still takes place, but the condenser effect is preponderating. It goes, of course, without saying that the heating of the glass in such a case is principally due to the bombardment of the molecules, partly also to leakage or conduction, but it is an undeniable fact that the glass may also be heated merely by the molecular displacement. The interesting feature in my experiment was that a lamp would light up when brought near to an induction coil, and that it could be held in the hand and the filament brought to incandescence.

Experiments of the kind described I have followed up for a long time with some practical objects in view. In connection with the experiment described by Prof. Thomson, it may be of interest to mention a very pretty phenomenon which may be observed with an incandescent lamp. If a lamp be immersed in water as far as practicable, and the filament and the vessel connected to the terminals of an induction coil operated from a machine such as I have used in my experiments, one may see the dull red filament surrounded by a very luminous globe, around which there is a less luminous space. The effect is probably due to reflection, as the globe is sharply defined, but may also be due to a "dark space;" at any rate it is so pretty that it must be seen to be appreciated.

Prof. Thomson has misunderstood my statement about the limit of audition. I was perfectly well aware of the fact that opinions widely differ on this point. Nor was I surprised to find that arcs of about 10,000 impulses per second emit a sound. My statement, "the curious is," etc., was only made in deference to an opinion expressed by Sir William Thomson. There was absolutely no stress laid on the precise number. The popular belief was that something like 10,000 to 20,000 per second, or 20,000 to 40,000 at the utmost, was the limit. For my argument this was immaterial; I contended that sounds of an incomparably greater number, that is, many times even the highest number, could be heard if they could be produced with sufficient power. My statement was only speculative, but I have devised means which I think may allow me to learn something definite on this point. I have not the least doubt that it is simply a question of power. A very short arc may be silent with 10,000 impulses per second, but just as soon as it is lengthened it begins to emit a sound. The vibrations are the same in number, but more powerful.

Prof. Thomson states that I am taking as the limit of "audition" sounds from 5,000 to 10,000 complete waves per second. There is nothing in my statements from which the above could be inferred, but Prof. Thomson has, perhaps, not thought that there are two sound vibrations for each complete current wave, the former being independent of the direction of the current.

I am glad to learn that Prof. Thomson agrees with me as to the causes of the persistence of the arc. Theoretical considerations a considerable time since had led me to the belief that arcs produced by currents of such high frequency would possess this and other desirable features. One of my objects in this direction has been to produce a practicable small arc. With these currents for many reasons much smaller arcs are practicable.

The interpretation by Prof. Thomson of my statements about the arc system leads me now—he will pardon me for saying it—to believe that what is most essential to the success of an arc system is good management. Nevertheless I feel confident of the correctness of the views expressed. The conditions in practice are so manifold that it is impossible for any type of machine to prove best under all the different conditions.

In one case when the circuit is many miles long, it is desirable to employ the most efficient machine with the least internal resistance; in another case such a machine would not be the best to employ. It will certainly be admitted that a machine of any type must have a greater resistance if intended to operate arc lights than if it is designed to supply incandescent lamps in series. When arc lights are operated and the resistance is small, the lamps are unsteady, unless a type of lamp is employed in which the carbons are separated by a mechanism which has no further influence upon the feed, the feeding being effected by an independent mechanism; but even in this case the resistance must be considerably greater to allow a quiet working of the lamps. Now, if the machine be such as to yield a steady current there is no way of attaining the desired result except by putting the required resistance somewhere either inside or outside of the machine. The latter is hardly practicable, for the customer may stand a hot machine, but he looks with suspicion upon a hot resistance box. A good automatic regulator, of course, improves the machine and permits the reduction of the internal resistance to some extent, but not as far as would be desirable. Now since resistance is loss, we can advantageously replace resistance in the machine by any equivalent impedance. But to produce a great impedance with small ohmic resistance it is necessary to have self-induction and variation of current, and the greater the self-induction and the rate of change of the current, the greater the impedance may be made, while the ohmic resistance may be very small. It must also be remarked that the impedance of the circuit external to the machine is likewise increased. As regards the increase in ohmic resistance in consequence of the variation of the current, this is, in the commercial machines now in use, very small. Clearly then a great advantage is gained by providing self-induction in the machine circuit and undulating the current, for it is possible to replace a machine which has a resistance of, say, 16 ohms by one which has no more than 2 or 3 ohms, and the lights will work even steadier. It seems to me, therefore, that my saying that self-induction is essential to the commercial success of an arc system is justified. What is still more important, such a machine will cost considerably less. But to realize fully the benefits it is preferable to employ an alternate current machine, as in this case a greater rate of change in the current is obtainable. Just what the ratio of resistance to impedance is in the Brush and Thomson machines is nowhere stated, but I think that it is smaller in the Brush machine, judging from its construction.

As regards the better working of clutch lamps with undulating currents, there is, according to my experience, not the least doubt about it. I have proved it on a variety of lamps to the complete satisfaction not only of myself but of many others. To see the improvement in the feed due to the jar of the clutch at its best it is desirable to employ a lamp in which an independent clutch mechanism effects the feed, and the release of the rod is independent of the up and down movement. In such a lamp the clutch has a small inertia and is very sensitive to vibrations, whereas if the feed is affected by the up and down movement of the lever carrying the rod, the inertia of the system is so great that it is not affected as much by vibrations, especially if, as in many cases, a dash-pot is employed. During the year 1885 I perfected such a lamp which was calculated to be operated with undulating currents. With about 1,500 to 1,800 current impulses per minute, the feed of this lamp is such that absolutely no movement of the rod can be observed, even if the arc be magnified fifty-fold by means of a lens, whereas if a steady current is employed the lamp feeds by small steps. I have, however, demonstrated this feature on other types of lamps, among them being a derived circuit lamp such as Prof. Thomson refers to. I conceived the idea of such a lamp early in 1884, and when my first company was started this was the first lamp I perfected. It was not until the lamp was ready for manufacture that, on receiving copies of application from the Patent Office, I learned for the first time, not having had any knowledge of the state of the art in America, that Prof. Thomson had anticipated me and had obtained many patents on this principle, which, of course, greatly disappointed and embarrassed me at that time. I observed the improvement of the feed with undulating currents on that lamp, but I recognized the advantage of providing a light and independent clutch unhampered in its movements. Circumstances did not allow me to carry out at that time some designs of machines I had in mind, and with the existing machines the lamp has worked at a great disadvantage. I cannot agree with Prof. Thomson that small vibrations would benefit a clockwork lamp as much as a clutch lamp; in fact, I think that they do not at all benefit a clockwork lamp. It would be interesting to learn the opinion of Mr. Charles F. Brush on these points.

Prof. Thomson states that he has run with perfect success clutch lamps "in circuit with coils of such large self-induction that any but very slight fluctuations were wiped out." Surely Prof. Thomson does not mean to say that self-induction wiped out the periodical fluctuation of the current. For this just the opposite quality, namely, capacity, is required. The self-induction of the coils in this case simply increased the impedance and variations occurring at large time intervals, which take place when the resistance in circuit with the lamps is too small, or even with larger resistance in circuit when the dash-pots either in the lamps or elsewhere are too loose.

Prof. Thomson further states that, in a lamp in which the feed mechanism is under the control of the derived circuit magnet only, the fluctuations pass through the arc without affecting the magnet to a perceptible degree. It is true that the variations of the resistance of the arc in consequence of the variations in the current strength are such as to dampen the fluctuation. Nevertheless, the periodical fluctuations are transmitted through the derived circuit, as one may convince himself easily by holding a thin plate of iron against the magnet.

In regard to the physiological effects of the currents, I may state that upon reading the memorable lecture of Sir William Thomson, in which he advanced his views on the propagation of the alternate current through conductors, it instantly occurred to me that currents of high frequencies would be less injurious. I have been looking for a proof that the mode of distribution through the body is the cause of the smaller physiological effects. At times I have thought that I was able to locate the pain in the outer portions of the body, but it is very uncertain. It is most certain, however, that the feeling with currents of very high frequencies is somewhat different from that with low frequencies. I have also noted the enormous importance of one being prepared for the shock or not. If one is prepared the effect upon the nerves is not nearly as great as when unprepared. With alternations as high as 10,000 per second and upward, one feels but little pain ... central portion of the body. A remarkable ... such currents of high tension is that one ... instantly he touches the wire, but beyond that the ... hardly noticeable.

But since the potential difference across the body ... given current through it is very small, the effect ... be very well ascribed to the surface distribution ... current, and the excessively low resistance of the ... such rapidly varying currents speaks rather for ... action.

In regard to the suggestion of Dr. Tatum, which ... Thomson mentions in another article in the ... issue of THE ELECTRICAL WORLD, I would state ... have constructed machines with as many as ... from which it is possible to obtain about 30,000 alternations per second, and perhaps more. I have also designed types of machines in which the field would revolve in the opposite direction to the armature, by which means it would be possible to obtain from a similar machine ... alternations per second or more.

I value highly the appreciation by Prof. Thomson of my work, but I must confess that in his conclusion he makes a most astounding statement as to the motives of my critical remarks. I have never for a moment thought that such remarks would be dictated by anything but friendly motives. Often we are forced in daily life to represent opposing interests or opinions, but surely in the higher walks ... feelings of friendship and mutual consideration should not be affected by such things as these.

The Construction and Care of Electric Railroads.—II. —General Remarks on Line Construction, etc.

BY ARTHUR E. COLGATE.

This article consists largely of some general remarks and formulæ relative to the amount of power lost in overcoming the resistance of the trolley and feed wires, and the locating of the poles, together with various other formulæ which may prove useful to the constructor. The power which may be said to be lost in this manner is in reality spent in heating the conductors, and is easily calculated by the formula,

$$\frac{C^2 R}{746} = \text{the horse power lost.}$$

The resistance of a copper wire is very nearly what is expressed by the formula 32.37 times its length in yards, divided by the square of its diameter in thousandths of an inch; and for other metals the resistance may be found in the same manner, the constant being changed according to the relative conductivity compared to that of copper. For example, if the conductivity is half that of copper, the constant should be multiplied by two. The formula is based on the resistance of a copper wire one yard long and of one circular mil sectional area, and as the conductivity of silicon bronze and most other trolley wires is about from 35 to ... per cent. higher than that of copper, either the constant or the result should be multiplied by 1 plus the per cent. increase of resistance.

Where feed wires are run in connection with the trolley lines, and are cross connected with them at short distances, the joint resistance may be considered as that of one conductor, whose resistance is equal to the product of the several resistances divided by their sum, and the loss of power calculated in the same manner as it would be in one wire. The loss permissible on a line depends greatly on the grade and cost of power. In most cases, where coal is reasonable, it is about 25 per cent. of the total amount developed by the generators, and on grades it should be much less, the current being supplied at these points by a separate feed wire, and a circuit-breaker being put in both trolley lines at the top and bottom of the hill, if it is a short one; and if it is sufficiently long to warrant it, the circuit should be again broken in the centre of the grade. The object of this is to protect the rest of the system should any car motor burn out or the line become grounded through defective car wiring, the insulation of which would be liable to give way and ground the line when subjected to heavy service on grades.

The weight of copper wire is about equal to the square of its diameter in thousandths of an inch multiplied by the constant (which is .016), and its tensile strength 11 times the radius in thousandths of an inch squared multiplied by the strength of a square inch of the material, which, in the case of copper, is 61,200 pounds, and in the case of iron 103,000 pounds. The strength of cable wire is about 9 per cent. more than that of the various strands of which it is composed, and the strength of rope is expressed by the circumference squared multiplied by the constant, which is for white rope 1,140 and for manilla 378, the strength of tarred ropes being about 10 per cent. less. The weight of round iron poles is 2.65 times the mean outside diameter squared divided by the square of the internal diameter multiplied by the length of the pole.

Where the use of untried apparatus is contemplated, tests as to the relative strength and durability under strain should be made by means of a testing machine. Imagine a case in which a log of wood about ten feet long and eight inches in diameter is held in an upright position by suitable means. Projecting pieces of wood, are bolted to the log by inch bolts or lag

FIG. 1.—TESTING A POLE.

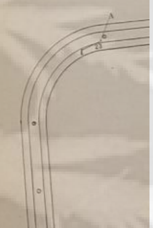


FIG. 2.—LOCATING

be performed with a steady difference of potential between the water and the carbon strip, in which case, of course, conduction through the glass takes place, the difference of potential required being in proportion to the thickness of the glass. With 5,000 alternations per second conduction still takes place, but the condenser effect is preponderating. It goes, of course, without saying that the heating of the glass in such a case is principally due to the bombardment of the molecules, partly also to leakage or conduction, but it is an undeniable fact that the glass may also be heated merely by the molecular displacement. The interesting feature in my experiment was that a lamp would light up when brought near to an induction coil, and that it could be held in the hand and the filament brought to incandescence.

Experiments of the kind described I have followed up for a long time with some practical objects in view. In connection with the experiment described by Prof. Thomson, it may be of interest to mention a very pretty phenomenon which may be observed with an incandescent lamp. If a lamp be immersed in water as far as practicable, and the filament and the vessel connected to the terminals of an induction coil operated from a machine such as I have used in my experiments, one may see the dull red filament surrounded by a very luminous globe, around which there is a less luminous space. The effect is probably due to reflection, as the globe is sharply defined, but may also be due to a "dark space;" at any rate it is so pretty that it must be seen to be appreciated.

Prof. Thomson has misunderstood my statement about the limit of audition. I was perfectly well aware of the fact that opinions widely differ on this point. Nor was I surprised to find that arcs of about 10,000 impulses per second emit a sound. My statement, "the curious is," etc., was only made in deference to an opinion expressed by Sir William Thomson. There was absolutely no stress laid on the precise number. The popular belief was that something like 10,000 to 20,000 per second, or 20,000 to 40,000 at the utmost, was the limit. For my argument this was immaterial; I contended that sounds of an incomparably greater number, that is, many times even the highest number, could be heard if they could be produced with sufficient power. My statement was only speculative, but I have devised means which I think may allow me to learn something definite on this point. I have not the least doubt that it is simply a question of power. A very short arc may be silent with 10,000 impulses per second, but just as soon as it is lengthened it begins to emit a sound. The vibrations are the same in number, but more powerful.

Prof. Thomson states that I am taking as the limit of "audition" sounds from 5,000 to 10,000 complete waves per second. There is nothing in my statements from which the above could be inferred, but Prof. Thomson small. It must also be remarked that the impedance of the circuit external to the machine is likewise increased. As regards the increase in ohmic resistance in consequence of the variation of the current, this is, in the commercial machines now in use, very small. Clearly then a great advantage is gained by providing self-induction in the machine circuit and undulating the current, for it is possible to replace a machine which has a resistance of, say, 16 ohms by one which has no more than 2 or 3 ohms, and the lights will work even steadier. It seems to me, therefore, that my saying that self-induction is essential to the commercial success of an arc system is justified. What is still more important, such a machine will cost considerably less. But to realize fully the benefits it is preferable to employ an alternate current machine, as in this case a greater rate of change in the current is obtainable. Just what the ratio of resistance to impedance is in the Brush and Thomson machines is nowhere stated, but I think that it is smaller in the Brush machine, judging from its construction.

As regards the better working of clutch lamps with undulating currents, there is, according to my experience, not the least doubt about it. I have proved it on a variety of lamps to the complete satisfaction not only of myself but of many others. To see the improvement in the feed due to the jar of the clutch at its best it is desirable to employ a lamp in which an independent clutch mechanism effects the feed, and the release of the rod is independent of the up and down movement. In such a lamp the clutch has a small inertia and is very sensitive to vibrations, whereas if the feed is affected by the up and down movement of the lever carrying the rod, the inertia of the system is so great that it is not affected as much by vibrations, especially if, as in many cases, a dash-pot is employed. During the year 1885 I perfected such a lamp which was calculated to be operated with undulating currents. With about 1,500 to 1,800 current impulses per minute, the feed of this lamp is such that absolutely no movement of the rod can be observed, even if the arc be magnified fifty-fold by means of a lens, whereas if a steady current is employed the lamp feeds by small steps. I have, however, demonstrated this feature on other types of lamps, among them being a derived circuit lamp such as Prof. Thomson refers to. I conceived the idea of such a lamp early in 1884, and when my first company was started this was the first lamp I perfected. It was not until the lamp was ready for manufacture that, on receiving copies of application from the Patent Office, I learned for the first time, not having had any knowledge of the state of the art in America, that Prof. Thomson had anticipated me and had obtained many patents on this principle, which, of course, greatly disappointed and embarrassed me at that time. I observed the improvement of the feed per second and upward, one feels but little pain in the central portion of the body. A remarkable feature of such currents of high tension is that one receives a burn instantly he touches the wire, but beyond that the pain is hardly noticeable.

But since the potential difference across the body by a given current through it is very small, the effects cannot be very well ascribed to the surface distribution of the current, and the excessively low resistance of the body to such rapidly varying currents speaks rather for a condenser action.

In regard to the suggestion of Dr. Tatum, which Prof. Thomson mentions in another article in the same issue of THE ELECTRICAL WORLD, I would state that I have constructed machines with as many as 480 poles, from which it is possible to obtain about 30,000 alternations per second, and perhaps more. I have also designed types of machines in which the field would revolve in an opposite direction to the armature, by which means it would be possible to obtain from a similar machine 60,000 alternations per second or more.

I value highly the appreciation by Prof. Thomson of my work, but I must confess that in his conclusion he makes a most astounding statement as to the motives of his critical remarks. I have never for a moment thought that his remarks would be dictated by anything but friendly motives. Often we are forced in daily life to represent opposing interests or opinions, but surely in the higher aims the feelings of friendship and mutual consideration should not be affected by such things as these.

The Construction and Care of Electric Railroads: II.—General Remarks on Line Construction, etc.

BY ARTHUR E. COLGATE.

This article consists largely of some general remarks and formulæ relative to the amount of power lost in overcoming the resistance of the trolley and feed wires, and the locating of the poles, together with various other formulæ which may prove useful to the constructor. The power which may be said to be lost in this manner is in reality spent in heating the conductors, and is easily calculated by the formula,

$$\frac{C^2 R}{746} = \text{the horse power lost.}$$

The resistance of a copper wire is very nearly what is expressed by the formula 32.37 times its length in yards, divided by the square of its diameter in thousandths of an inch; and for other metals the resistance may be found in the same manner, the constant being changed according to the relative conductivity compared to that of copper. For example, if the conductivity is half that of copper, the constant

number, could be heard if they could be produced with sufficient power. My statement was only speculative, but I have devised means which I think may allow me to learn something definite on this point. I have not the least doubt that it is simply a question of power. A very short arc may be silent with 10,000 impulses per second, but just as soon as it is lengthened it begins to emit a sound. The vibrations are the same in number, but more powerful.

Prof. Thomson states that I am taking as the limit of "audition" sounds from 5,000 to 10,000 complete waves per second. There is nothing in my statements from which the above could be inferred, but Prof. Thomson has, perhaps, not thought that there are two sound vibrations for each complete current wave, the former being independent of the direction of the current.

I am glad to learn that Prof. Thomson agrees with me as to the causes of the persistence of the arc. Theoretical considerations a considerable time since had led me to the belief that arcs produced by currents of such high frequency would possess this and other desirable features. One of my objects in this direction has been to produce a practicable small arc. With these currents for many reasons much smaller arcs are practicable.

The interpretation by Prof. Thomson of my statements about the arc system leads me now—he will pardon me for saying it—to believe that what is most essential to the success of an arc system is good management. Nevertheless I feel confident of the correctness of the views expressed. The conditions in practice are so manifold that it is impossible for any type of machine to prove best under all the different conditions.

In one case when the circuit is many miles long, it is desirable to employ the most efficient machine with the least internal resistance; in another case such a machine would not be the best to employ. It will certainly be admitted that a machine of any type must have a greater resistance if intended to operate arc lights than if it is designed to supply incandescent lamps in series. When arc lights are operated and the resistance is small, the lamps are unsteady, unless a type of lamp is employed in which the carbons are separated by a mechanism which has no further influence upon the feed, the feeding being effected by an independent mechanism; but even in this case the resistance must be considerably greater to allow a quiet working of the lamps. Now, if the machine be such as to yield a steady current there is no way of attaining the desired result except by putting the required resistance somewhere either inside or outside of the machine. The latter is hardly practicable, for the customer may stand a hot machine, but he looks with suspicion upon a hot resistance box. A good automatic regulator, of course, improves the machine and permits the reduction of the internal resistance to some extent, but not as far as would be desirable. Now since resistance is loss, we can advantageously replace resistance in the machine by any equivalent impedance. But to produce a great impedance with small ohmic resistance it is necessary to have self-induction and variation of current, and the greater the self-induction and the rate of change of the current, the greater the impedance may be made, while the ohmic resistance may be very small steps. I have, however, demonstrated this feature on other types of lamps, among them being a derived circuit lamp such as Prof. Thomson refers to. I conceived the idea of such a lamp early in 1884, and when my first company was started this was the first lamp I perfected. It was not until the lamp was ready for manufacture that, on receiving copies of application from the Patent Office, I learned for the first time, not having had any knowledge of the state of the art in America, that Prof. Thomson had anticipated me and had obtained many patents on this principle, which, of course, greatly disappointed and embarrassed me at that time. I observed the improvement of the feed with undulating currents on that lamp, but I recognized the advantage of providing a light and independent clutch unhampered in its movements. Circumstances did not allow me to carry out at that time some designs of machines I had in mind, and with the existing machines the lamp has worked at a great disadvantage. I cannot agree with Prof. Thomson that small vibrations would benefit a clockwork lamp as much as a clutch lamp: in fact, I think that they do not at all benefit a clockwork lamp. It would be interesting to learn the opinion of Mr. Charles F. Brush on these points.

Prof. Thomson states that he has run with perfect success clutch lamps "in circuit with coils of such large self-induction that any but very slight fluctuations were wiped out." Surely Prof. Thomson does not mean to say that self-induction wiped out the periodical fluctuation of the current. For this just the opposite quality, namely, capacity, is required. The self-induction of the coils in this case simply increased the impedance and variations occurring at large time intervals, which take place when the resistance in circuit with the lamps is too small, or even with larger resistance in circuit when the dash-pots either in the lamps or elsewhere are too loose.

Prof. Thomson further states that, in a lamp in which the feed mechanism is under the control of the derived circuit magnet only, the fluctuations pass through the arc without affecting the magnet to a perceptible degree. It is true that the variations of the resistance of the arc in consequence of the variations in the current strength are such as to dampen the fluctuation. Nevertheless, the periodical fluctuations are transmitted through the derived circuit, as one may convince himself easily by holding a thin plate of iron against the magnet.

In regard to the physiological effects of the currents, I may state that upon reading the memorable lecture of Sir William Thomson, in which he advanced his views on the propagation of the alternate current through conductors, it instantly occurred to me that currents of high frequencies would be less injurious. I have been looking for a proof that the mode of distribution through the body is the cause of the smaller physiological effects. At times I have thought that I was able to locate the pain in the outer portions of the body, but it is very uncertain. It is most certain, however, that the feeling with currents of very high frequencies is somewhat different from that with low frequencies. I have also noted the enormous importance of one being prepared for the shock or not. If one is prepared the effect upon the nerves is not nearly as great as when unprepared. With alternations as high as 10,000

which may be said to be lost in this manner is in reality spent in heating the conductors, and is easily calculated by the formula,

$$\frac{C^2 R}{746} = \text{the horse power lost.}$$

The resistance of a copper wire is very nearly what is expressed by the formula 32.37 times its length in yards, divided by the square of its diameter in thousandths of an inch; and for other metals the resistance may be found in the same manner, the constant being changed according to the relative conductivity compared to that of copper. For example, if the conductivity is half that of copper, the constant should be multiplied by two. The formula is based on the resistance of a copper wire one yard long and of one circular mil sectional area, and as the conductivity of silicon bronze and most other trolley wires is about from 25 to 40 per cent. higher than that of copper, either the constant or the result should be multiplied by 1 plus the per cent. increase of resistance.

Where feed wires are run in connection with the trolley lines, and are cross connected with them at short distances, the joint resistance may be considered as that of one conductor, whose resistance is equal to the product of the several resistances divided by their sum, and the loss of power calculated in the same manner as it would be in one wire. The loss permissible on a line depends greatly on the grade and cost of power. In most cases, where coal is reasonable, it is about 25 per cent. of the total amount developed by the generators, and on grades it should be much less, the current being supplied at these points by a separate feed wire, and a circuit-breaker being put in both trolley lines at the top and bottom of the hill, if it is a short one; and if it is sufficiently long to warrant it, the circuit should be again broken in the centre of the grade. The object of this is to protect the rest of the system should any car motor burn out or the line become grounded through defective car wiring, the insulation of which would be liable to give way and ground the line when subjected to heavy service on grades.

The weight of copper wire is about equal to the square of its diameter in thousandths of an inch multiplied by the constant (which is .016), and its tensile strength 11 times its radius in thousandths of an inch squared multiplied by the strength of a square inch of the material, which, in the case of copper, is 61,200 pounds, and in the case of iron 103,000 pounds. The strength of cable wire is about 10 per cent. more than that of the various strands of which it is composed, and the strength of rope is expressed by the circumference squared multiplied by the constant, which is for white rope 1,140 and for manila 810, the strength of tarred ropes being about 10 per cent. less. The weight of round iron poles is 2.65 times the mean outside diameter squared divided by the square of the internal diameter multiplied by the length of the pole.

Where the use of untried apparatus is contemplated, tests as to the relative strength and durability under strain should be made by means of a testing machine. Imagine a case in which a log of wood about ten feet long and eight inches in diameter is held in an upright position by suitable means. Projecting pieces of wood, are bolted to the log by inch bolts or lag

rent stations could have it for the asking, it is never used. At present, however, we are using alternating currents in just about the worst way that could be possibly devised.

CONDENSERS.

Condensers frequently figure in electric light literature, but they are only put forward as possible means for transforming currents. Direct currents and interrupters are generally discussed. Condensers may, however, have another very large opening in connection with ordinary alternate current distribution. Take, for instance, the case of arc lamps. It is customary, whenever possible, to run arc lamps in long series with high pressures, generally with direct currents. In many cases such an arrangement is very convenient; but wherever there are incandescent lamps to be fed at the same places as the arcs, it is, of course, wasteful to run two sets of engines, dynamos and leads. With direct currents this is sometimes necessary, for arc lamps in parallel do not burn well on 100-volt circuits, and must be used two at a time; and at 50 volts resistance is needed in series, which is wasteful. With alternate currents nothing is easier than to run lamps with choking coils. If the supply is high pressure, each lamp can have its own transformer, and the transformer can be wound for nearly constant secondary current. Prof. E. Thomson has brought out several forms of constant-current transformer, and so has Mr. Tesla. The "hedgehog" form, however, lends itself especially well; all that is necessary is winding the coils one at each end, instead of one over the other. Whether the mains are high or low pressure, choking coils or constant-current transformers will give rise to large currents at the station, which will lower the output of the machines.

For instance, suppose a station supplies a 100-volt secondary circuit by means of transformers with 2,000 volts primary pressure; and suppose there are 200 arc lamps, each taking 33 volts and 10 ampères, arranged on the 100-volt circuit, with a choking coil in series with each. Suppose, for simplicity, that there are no incandescent lamps in use. The arc lamps then take 2,000 ampères and 100 volts; but this does not amount to more than 66,000 watts, as the current is not in step with the electromotive force. The dynamos thus have to supply 2,000 volts and 100 ampères; whereas the same power, if the current did not lag, would be supplied with 2,000 volts and 33 ampères. This gives rise to several troubles. Suppose each machine has an armature wound to give 2,000 volts and 33 ampères, or 66,000 watts, it takes three instead of one to work the lamps. In addition to this, the lagging of the current weakens the field of the dynamos, so that they need more excitation to give 2,000 volts than they would need even on full load on a non-inductive resistance. Moreover, running three engines and dynamos at a third load instead of one at full load is not economical. A condenser takes a current which leads relatively to the pressure, so that it counteracts the effect of the lagging current. The 100 ampères may be regarded as compounded of 33 ampères in step with the pressure, and 95 ampères lagging a quarter of a period. A condenser of about 85 microfarads will supply the 95-ampère component, while one dynamo supplies the 33 ampères really needed by the lamps. This reasoning holds good without the curve of sines assumption.

The use of condensers to overcome troubles arising from exciting or magnetizing currents of closed or open circuit transformers has already been mentioned.

They may also be used to increase the output of dynamos. As already explained, even if a dynamo is worked on resistance, the cross induction causes the current to lag, and the back induction weakens the field. If a condenser is put in shunt to the terminals of the machine, its current strengthens the field again and increases the terminal pressure, and therefore the output. If the condenser is large enough, and if the armature actions are great enough it might be possible to make a machine excite itself without any field winding at all. This action of a condenser on a dynamo may be equally easily explained on the self-induction theory. The difference between the two theories may be shown here, however. According to the self-induction theory, if the condenser is large enough to produce resonance—that is to say, when $(2 \pi n)^2 L K = 1$—the output increases till the current is as great as if the no-load pressure of the machine were short-circuited on the armature resistance. According to the armature reaction theory, the machine increases its field till the field magnets become more saturated; in fact, the machine is like a direct-current shunt-wound dynamo which has a low-resistance shunt. I do not wish to go into this matter further here, for it might lead to a discussion of a rise in the Deptford mains—a subject which will be treated, I am informed, in a forthcoming paper, and will certainly receive full justice at the hands of the authors.

The commercial manufacture of high-pressure condensers is not so easy as might be supposed. Knowing the difficulties there are in insulating leads and mains—in which thick insulation is permissible, and, in fact, advisable—it may be realized that to insulate many hundreds of square feet of metallic surface with the thinnest possible material is anything but an easy problem. In addition to being a good insulator, the dielectric must be free from "absorption." Some account of my work on condensers has lately been given.* Mr. W. F. Bourne, who has carried out all the experiments, has tried almost every conceivable kind of dielectric, and finds a kind of paper called "butter-skin," soaked in paraffine oil, the best material. It is curious that this particular kind of paper is specially made so as to be grease-proof. Some kinds of bank post paper worked nearly as well, but it is too expensive for commercial use. It seems as if the paper must be relied upon for insulation, not the paraffine. The condensers are simple cast-iron boxes containing numbers of sheets of paper and tinfoil. Lids are fitted on and made tight.

*Phil. Mag., February, 1891.

TOWN LIGHTING.

Alternate arc lamps have already been discussed to some extent. In some places, especially in small towns, it is usual to have special circuits for the town lighting which are shut off during the day. It is needless to point out that, if the low-pressure network is used, condensers at the station allow arc lamps to be run with choking coils, and incandescent lamps can be run direct and it is no more necessary to run special mains for the street lighting than it is needful to put down two sets of gas pipes in a town. Sometimes, however, high pressure mains are used. Each arc lamp can then have its own constant-current transformer. If incandescent lamps are used, the plan generally adopted is using a transformer for every 10 or 20 lamps. If the wires are underground, this involves great expense; and if overhead, it means both expense and unsightliness. A small "hedgehog" transformer has been designed to meet this particular want. It is so small that it can be worked into the design of the lamp-holder or shade, and one can be used for each lamp.

In America alternating arc lamps are run in series, with a series transformer for each. This arrangement is quite unnecessary for places where there is incandescent lighting too It has the advantage of allowing series arcs without bringing high pressures into the lamps. It has no other advantage over direct series lighting. The dynamo used by the Westinghouse Company is made to give nearly constant current. This is a barbarous arrangement. It is a reversion to the old alternating machines of 1[illegible] years ago, which gave approximately constant current. All that is needed is great armature reaction, and hence a large machine for the output. The economical way of getting constant current is to use a good dynamo, and to take the governor off the engine, or to use it as a safeguard against racing only. If the Westinghouse machine has only quarter load on, it still goes at full speed, using nearly full steam, and wearing everything out. With a constant-pressure dynamo it would run at quarter speed, each cylinderful of steam being used economically and being expanded properly. To put a constant-speed governor on the engine, and then to design a special dynamo to get over the difficulties you have introduced, is a very common proceeding with direct-current arcs also.

Alternating constant currents have, however, one advantage over direct that I think is not realized. Synchronizing motors will run perfectly on series constant-current circuits; and as they run at constant speed, there is no racing, or trouble about governing, as in the case of direct currents. Of course, constant speed of engine is here necessary to give constant frequency. Many people seem to have gathered from Dr. Hopkinson's paper that series alternating motors will not run; but this is a false inference.

Phenomena of Alternating Currents of Very High Frequency.

BY NIKOLA TESLA.

I cannot pass without comment the note of Prof. Thomson in THE ELECTRICAL WORLD of April 4, although I dislike very much to engage in a prolonged controversy. I would gladly let Prof. Thomson have the last word, were it not that some of his statements render a reply from me necessary.

I did not mean to imply that whatever work Prof. Thomson has done in alternating currents of very high frequency was subsequent to his letter published in *The Electrician*. I thought it possible, and even probable, that he had made his experiments some time before, and my statement in regard to this was meant in this general way. It is more than probable that quite a number of experimenters have built such machines and observed effects similar to those described by Prof. Thomson. It is doubtful, however, whether, in the absence of any publication on this subject, the luminous phenomena described by me have been observed by others, the more so as very few would be likely to go to the trouble I did, and I would myself not have done so had I not had an advance of firm conviction gained from the study of the works of the most advanced thinkers that I would obtain the results sought for. Now that I have indicated the direction, many will probably follow, and for this very purpose I have shown some of the results I have reached.

Prof. Thomson states decisively in regard to the experiment with the incandescent lamp bulb and the filament mounted on a single wire that he cannot agree with me at all that conduction through the glass has anything to do with the phenomenon observed. He mentions the well-known fact that an incandescent lamp acts as a Leyden jar and says that "if conduction through the glass were a possibility this action could not occur." I think I may confidently assert that very few electricians will share this view. For the possibility of the condenser effect taking place it is only necessary that the rate at which the charges can equalize through the glass by conduction should be somewhat below the rate at which they are so stored.

Prof. Thomson seems to think that conduction through the glass is an impossibility. Has he then never measured insulation resistance, and has he then not measured it by means of a conduction current? Does he think that there *is* such a thing as a perfect non-conductor among the bodies we are able to perceive? Does he not think that as regards conductivity there can be question only of degree? If glass were a perfect non-conductor, how could we account for the conduction through a glass condenser when subjected to steady differences of potential?

While not directly connected with the present controversy I would here point out that there exists a popular error in regard to the properties of dielectric bodies. Many electricians frequently confound the theoretical dielectric of Maxwell with the dielectric bodies in use. They do not stop to think that the only perfect dielectric is ether, and that all other bodies, the existence of which is known to us, must be conductors, judging from their physical properties.

My statement that conduction is concerned to some, although perhaps negligible, extent in the experiment above described was, however, made not only on account of the fact that all bodies conduct more or less, but principally on account of the heating of the glass during the experiment. Prof Thomson seems to overlook the fact that the insulating power of glass diminishes enormously with the increase in temperature, so much so that melted glass is comparatively an excellent conductor. I have, moreover, stated in my first reply to Prof Thomson in THE ELECTRICAL WORLD of March 21, 1891, that the same experiment can be performed by means of an unvarying difference of potential. In this case it must be assumed that some such process as conduction through the glass takes place, and all the more as it is possible to show by experiment that with a sufficiently high steady difference of potential enough current can be passed through the glass of a condenser with mercury coatings to light up a Geissler tube joined in series with the condenser. When the potential is alternating the condenser action comes in, and conduction becomes insignificant, and the more so the greater the rate of alternation or change per unit of time. Nevertheless, in my opinion, conduction must always exist, especially if the glass is hot, although it may be negligible with very high frequencies.

Prof. Thomson states further that, from his point of view, I have misunderstood his statement about the limit of audition. He says that 10,000 to 20,000 alternations correspond to 5,000 to 10,000 complete waves of sound. In my first reply to Prof. Thomson's remarks (in THE ELECTRICAL WORLD of March 21, 1891) I avoided pointing out directly that Prof. Thomson was mistaken, but now I see no way out of it. Prof. Thomson will pardon me if I call his attention to the fact he seems to disregard, namely, that 10,000 to 20,000 alternations of current in an arc—which was the subject under discussion—does not mean 5,000 to 10,000, but 10,000 to 20,000 *complete waves of sound*.

He says that I have adopted or suggested as the limit of audition 10,000 waves per second; but I have neither adopted nor suggested it. Prof. Thomson states that I have been working with 5,000 to 10,000 complete waves, while I have nowhere made any such statement. He says that this would be working below the limit of audition, and cites as an argument that at the Central High School in Philadelphia he has heard 20,000 waves per second; but he wholly overlooks a point on which I have dwelt at some length—namely, that the limit of audition of an arc is something entirely different from the limit of audition in general.

Prof. Thomson further states, in reply to some of my views expressed in regard to the constant current machines, that five or six years ago it occurred to him to try the construction of a dynamo for constant current, in which "the armature coils were of a highly efficient type, that is, of comparatively short wire length for the voltage and moving in a dense magnetic field." Exteriorly to the coils and to the field he had placed in the circuit of each coil an impedance coil which consisted of an iron core wound with a considerable length of wire and connected directly in circuit with the armature coil. He thus obtained, he thought, "the property of considerable self-induction along with efficient current generation." Prof. Thomson says he expected "that possibly the effects would be very much the same as those obtainable from the regularly constructed apparatus." But he was *disappointed*, he adds. With all the consideration due to Prof. Thomson I would say that to expect a good result from such a combination was rather sanguine. Earth is not farther from Heaven than this arrangement is from one in which there would be a length of wire sufficient to give the same self-induction wound on the armature and utilized to produce useful E. M. F. instead of doing just the opposite, let alone the loss in the iron cores. But it is, of course, only fair to remember that this experiment was performed five or six years ago, when even the foremost electricians lacked the necessary information in these and other matters.

Prof. Thomson seems to think that self-induction wipes out the periodical undulations of current. Now self-induction does not produce any such affect, but, if anything,

it renders the undulations more pronounced. This is self-evident. Let us insert a self-induction coil in a circuit traversed by an undulating current and see what happens. During the period of the greatest rate of change when the current has a small value, the self-induction opposes more than during the time of the small rate of change and when the current is at or near its maximum value. The consequence is that with the same frequency the maximum value of the current becomes the greater, the greater the self-induction. As the sound in a telephone depends only on the maximum value it is clear that self-induction is the very thing required in a telephone circuit. The larger the self-induction the louder and clearer the speech, provided the same current is passed through the circuit. I have had ample opportunity to study this subject during my telephone experience of several years. As regards the fact that a self-induction coil in series with a telephone diminishes the loudness of the sound, Prof. Thomson seems to overlook that this effect is wholly due to the impedance of the coil, *i. e.*, to its virtue of diminishing the *current's strength*. But while the current's strength is diminished the undulation is rendered only more pronounced. Obviously, when comparisons are made they must be made with the same current.

In an arc machine such as that of Prof. Thomson's the effect is different. There one has to deal with a make and break. There are then two induced currents, one in the opposite the other in the same direction with the main current. If the function of the mechanism be the same, whether self-induction coil be present or not, the undulations could not possibly be wiped out. But Prof. Thomson seems likewise to forget that the effect is wholly due to the defect of the commutator; namely, the induced current of break—which is of the same direction with the main current and of great intensity when large self-induction is present—simply bridges the adjacent commutator segments, or if not entirely so, at least shortens the interval during which the circuit is open and thus reduces the undulation.

In regard to the improvement in the feeding of the lamps by vibration or undulations, Prof. Thomson expresses a decisive opinion. He now says that the vibrations *must* improve the feeding of a clockwork lamp. He says that I "contented myself by simply saying" that I cannot agree with him on that point.

Now, *saying it* is not the only thing I did. I have passed many a night watching a lamp feed, and I leave it to any skilled experimenter to investigate whether my statements are correct. My opinion is that a clockwork lamp—that is, a lamp in which the descent of the carbon is regulated not by a clutch or friction mechanism, but by an escapement—cannot feed any more perfectly than tooth by tooth, which may be a movement of, say, one-sixty-fourth of an inch or less. Such a lamp will feed in nearly the same manner, whether the current be perfectly smooth or undulating, provided the conditions of the circuit are otherwise stable. If there is any advantage I think it would be in the use of a smooth current, for with an undulating current the lamp is likely to miss some time and feed by more than one tooth. But in a lamp in which the descent of the carbon is regulated by friction mechanism, an undulating current of the proper number of undulations per second will always give a better result. Of course to realize fully the benefits of the undulating current the release ought to be effected independently of the up and down movement, as I have pointed out before.

In regard to the physiological effects Prof. Thomson says that in such a comparatively poor conductive material as animal tissue the distribution of current cannot be governed by self-induction to any appreciable extent, but he does not consider the two-fold effect of the large cross-section pointed out by Sir William Thomson. As the resistance of the body to such currents is low, we must assume either condenser action or induction of currents in the body.

The Stanley Transformer.

As alternating current apparatus has come into more and more general use it has gone through the same stages of evolution as has characterized direct current machines. The component parts of the system have been worked out more and more carefully, and more efficient types of the machines designed. It has taken some years of experiment to bring the alternating dynamo to its present high state of efficiency, and the other necessary part of the alternating system, that is, the secondary generator—the transformer—has gone through somewhat the same slow process of evolution. In the early stages of the art the transformer was inefficient and regulated badly. It was improperly designed and often poorly built. Gradually the principles involved in its construction came to be understood, the parts were better proportioned to serve their purpose, and a far better quality of iron was used for the core.

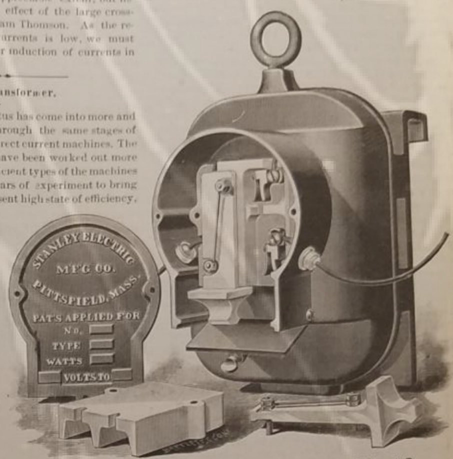


FIG. 2.—STANLEY ALTERNATING CURRENT TRANSFORMER.

We give on the present page two cuts of the very latest type of transformer. It is manufactured by the Stanley Mfg. Company from the designs of Mr. William Stanley, Jr., who has become so widely known through his connection with the rise and development of the Westinghouse system. Many of the fundamental patents of this company are the fruits of Mr. Stanley's inventive genius. In the transformer that he has just designed and put on the market there are no radical changes from existing types; it is the result of straightforward, earnest effort to make a thoroughly efficient, reliable and well constructed instrument. It is built for standard voltages and frequencies, to work on any system, and is placed upon the market on its merits. The design is very carefully worked out, and especially is the most extreme pains taken to obtain the best possible iron for the core. The result of this policy is evident in the tests that have been made of the finished product by Mr. Stanley, and which we have every reason to believe are correct. The efficiency for a 20-light transformer at full load is 94.3 per cent. The variation of electromotive force in the secondary is but 1.9 per cent. the leakage current but a twentieth of an ampère, while 12 watts of useful energy is secured per pound weight of the transformer. These results, considering the small size of the transformer tested, are satisfactory in the highest degree. In the method of winding employed particular pains was taken to avoid the chance of a cross between the primary and secondary coils, and a special insulating compound was developed to bring the insulation between the coils up to the highest practicable point. Of course all these precautions tend toward safety. Among minor practical details the arrangement of the fuses, shown in Fig. 2, is worth more than a passing notice. No secondary fuse at all is employed, inasmuch as a fusible cut-out is always inserted elsewhere in the secondary circuit. The primary fuse wire is carried on a porcelain block or plug and can be secured in place with great ease and rapidity. To replace a fuse which burns out it is only necessary to open the door in the front of the transformer by turning a thumbscrew, remove the plug, insert another and then close up the case again. Or, if desirable, a new fuse can be attached, and the same plug replaced. All sizes of transformers up to 100 lamps have interchangeable fuse plugs. It is worth noticing that it is not necessary to remove the whole front of the transformer to replace a fuse plug—merely dropping the door in the front, as shown in the cut—and no screw driver or other tools are required.

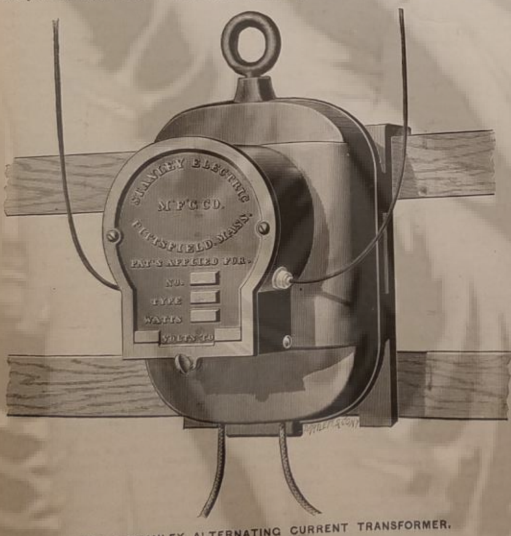


FIG. 1.—STANLEY ALTERNATING CURRENT TRANSFORMER.

Altogether there are many good points about this Stanley transformer, and not the least of them is that it is put on the market unconnected with any system, and unhampered by any peculiarities that compel its use in connection with other appliances. Most companies operating stations are in a position to make an intelligent choice in their selection of apparatus, and oftentimes the best results are obtained by building up a system in accordance with the particular needs of the place without rigid adherence to any one manufacturer.

Annual Report of the American Bell Telephone Company.

The annual report of the American Bell Telephone Company, for the year ending Dec. 31, 1890, shows as follows:

	1890.	1889.
Earnings.		
Rental of telephones	$2,913,768.63	$2,657,361.90
Dividends	1,256,271.79	1,230,5[illegible].33
Extra territorial and branch lines	89,472.12	82,553.63
Telegraph commission	26,491.60	22,3[illegible]
Interest	77,447.89	4,364.44
Miscellaneous	12,220.44	7,934.19
	$4,372,290.88	$4,044,704.71
Expenses.		
Operation	$311,437.98	$[illegible]9,493.37
Legal	12[illegible],359.08	144,56[illegible].62
Interest and taxes	237,174.81	221,190.97
Commission	575,721.92	511,[illegible]
Royalty	10,000.00	10,000.00
Concessions	228,873.94	221,288.11
Miscellaneous	[illegible]	3,702.61
	$1,3[illegible],871.33	$1,385,966.02
Net earnings	$2,869,418.35	$2,658,738.69

Comparative results may be presented thus:

	1890.	1889.	1888.
Gross earnings	$4,372,291	$4,044,705	$3,865,118
Expenses	1,503,873	1,385,966	1,45[illegible]
Net earnings	$2,869,418	$2,658,739	$2,414,305
Miscellaneous		3,450	12,258
Total net	$2,869,418	$2,6[illegible]	$2,426,563
Dividends, 18 per cent	2,333,913	1,8[illegible]	1,789,878
Surplus	$535,505	$822,976	$636,[illegible]
Reserve for general depreciation	400,000	600,000	600,000
Balance	$135,505	$222,976	$36,[illegible]
Reserve, depreciation instruments	55,[illegible]	100,000	46,555
Net surplus		$122,976	
Surplus ac. Dec. 31	$2,151,912	2,151,012	$2,028,036

Ledger balances Dec. 31, 1890, were as follows:

DEBTORS.		
Telephones	$919,274.94	
Real estate	744,033.00	
Stocks	32,748,580.03	
Merchandise and machinery	9,332.94	
Bills and accounts receivable	2,631,2[illegible]	
Cash and deposits	187,353.39	
CREDITORS.		
Capital stock		$12,500,000.00
Debenture bonds, 1888		2,000,000.00
*Bills and accounts payable		1,334,836.14
Patent account (profit and loss)		10,516,544.56
Profit and loss		5,343,131.11
Reserve		2,480,812.30
Surplus		2,151,911.61
	$34,636,236.32	$34,636,236.32

* Of this amount, $375,000 is the dividend payable Jan. 15, 1891, to stockholders of record Dec. 31, 1890.

a third load instead of
A condenser takes a
he pressure, so that it
current. The 100 am-
ed of 33 ampères in step
lagging a quarter of a
icrofarads will supply
e dynamo supplies the
amps. This reasoning
es assumption.
he troubles arising from
closed or open circuit
tioned.
ase the output of dyna-
if a dynamo is worked
auses the current to lag,
ne field. If a condenser
he machine, its current
increases the terminal
it. If the condenser is
ure actions are great
ke a machine excite it-
. This action of a con-
y easily explained on the
ce bet een the two theo-
According to the self-
is large enough to pro-
hen $(2\pi n)^2 L K = 1$ —
t is as great as if the no-
short-circuited on the
the armature reaction
field till the field mag-
t, the machine is like a
mo which has a low-
o go into this matter
discussion of a rise in
ch will be treated, I am
, and will certainly re-
e authors.
high-pressure condens-
pposed. Knowing the
leads and mains—in
le, and, in fact, advisa-
late many hundreds of
the thinnest possible
oblem. In addition to
r c must be free from
work on condensers has
ne, who has carried out
every conceivable kind

direct-current arcs also.

Alternating constant currents have, however, one advantage over direct that I think is not realized. Synchronizing motors will run perfectly on series constant-current circuits; and as they run at constant speed, there is no racing, or trouble about governing, as in the case of direct currents. Of course, constant speed of engine is here necessary to give constant frequency. Many people seem to have gathered from Dr. Hopkinson's paper that series alternating motors will not run; but this is a false inference.

Phenomena of Alternating Currents of Very High Frequency.

BY NIKOLA TESLA.

I cannot pass without comment the note of Prof. Thomson in THE ELECTRICAL WORLD of April 4, although I dislike very much to engage in a prolonged controversy. I would gladly let Prof. Thomson have the last word, were it not that some of his statements render a reply from me necessary.

I did not mean to imply that whatever work Prof. Thomson has done in alternating currents of very high frequency was subsequent to his letter published in *The Electrician*. I thought it possible, and even probable, that he had made his experiments some time before, and my statement in regard to this was meant in this general way. It is more than probable that quite a number of experimenters have built such machines and observed effects similar to those described by Prof. Thomson. It is doubtful, however, whether, in the absence of any publication on this subject, the luminous phenomena described by me have been observed by others, the more so as very few would be likely to go to the trouble I did, and I would myself not have done so had I not had an advance of firm conviction gained from the study of the works of the most advanced thinkers that I would obtain the results sought for. Now that I have indicated the direction, many will probably follow, and for this very purpose I have shown some of the results I have reached.

Prof. Thomson states decisively in regard to the experiment with the incandescent lamp bulb and the filament mounted on a single wire that he cannot agree with me at all that conduction through the glass has anything to do with the phenomenon observed. He mentions the well-known fact that an incandescent lamp acts as a Leyden jar and says that "if conduction through the glass were a possibility this action could not occur." I think I may confidently assert that very few electricians will share this view. For the possibility of the condenser effect taking place it is only necessary that the rate at which the

out directly that
now I see no way
don me if I call his
regard, namely, th
rent in an arc—wh
does not mean 5,00
waves of sound.
He says that I ha
audition 10,000 w
adopted nor sugg
I have been workin
while I have nowhe
that this would be
cites as an argumen
Philadelphia he has
wholly overlooks a
length—namely, tha
something entirely
general.
Prof. Thomson f
views expressed in
that five or six year
struction of a dynar
armature coils wer
comparatively short
ing in a dense ma
and to the field he h
impedance coil whic
a considerable leng
circuit with the ar
thought, "the p
tion along with
Thomson says
effects would be
obtainable from the
he was *disappointe*
due to Prof. Thom
result from such
Earth is not farther
from one in which
cient to give the sa
ture and utilized
doing just the oppo
But it is, of course,
ment was performe
foremost electrician
these and other ma
Prof. Thomson se
out the periodical u
tion does not prod

aper called "butter-skin," aterial. It is curious that pecially made so as to be bank post paper worked nsive for commercial use. rehed upon for insulation, sers are simple cast-iron ets of paper and tinfoil. t.

ITING.

ady been discussed to some in small towns, it is usual wn lighting which are shut s to point out that, if the condensers at the station choking coils, and incan- and it is no more neces- e street lighting than it o sets of gas pipes in a gh pressure mains are used. its own constant-current lamps are used, the plan nsformer for every 10 or 20 round, this involves great means both expense and lgehog" transformer has icular want. It is so small the design of the lamp- e used for each lamp.

mps are run in series, with This arrangement is quite here is incandescent light- f allowing series arcs with- the lamps. It has no other hting. The dynamo used is made to give nearly barous arrangement. It is g machines of 1 years ago, constant current. All armature reaction, and the output. The eco- nstant current is to use ke the governor off the rd against racing only. If s only quarter load on, it early full steam, and wear- onstant-pressure dynamo it h cylinderful of steam be- ng expanded properly. To on the engine, and then to

charges can equalize through the glass by conduction should be somewhat below the rate at which they are so stored.

Prof. Thomson seems to think that conduction through the glass is an impossibility. Has he then never measured insulation resistance, and has he then not measured it by means of a conduction current? Does he think that there *is* such a thing as a perfect non-conductor among the bodies we are able to perceive? Does he *not* think that as regards conductivity there can be question only of degree? If glass were a perfect non-conductor, how could we account for the conduction through a glass condenser when subjected to steady differences of potential?

While not directly connected with the present controversy I would here point out that there exists a popular error in regard to the properties of dielectric bodies. Many electricians frequently confound the theoretical dielectric of Maxwell with the dielectric bodies in use. They do not stop to think that the only perfect dielectric is ether, and that all other bodies, the existence of which is known to us, must be conductors, judging from their physical properties.

My statement that conduction is concerned to some, although perhaps negligible, extent in the experiment above described was, however, made not only on account of the fact that all bodies conduct more or less, but principally on account of the heating of the glass during the experiment. Prof Thomson seems to overlook the fact that the insulating power of glass diminishes enormously with the increase in temperature, so much so that melted glass is comparatively an excellent conductor. I have, moreover, stated in my first reply to Prof Thomson in THE ELECTRICAL WORLD of March 21, 1891, that the same experiment can be performed by means of an unvarying difference of potential. In this case it must be assumed that some such process as conduction through the glass takes place, and all the more as it is possible to show by experiment that with a sufficiently high steady difference of potential enough current can be passed through the glass of a condenser with mercury coatings to light up a Geissler tube joined in series with the condenser. When the potential is alternating the condenser action comes in, and conduction becomes insignificant, and the more so the greater the rate of alternation or change per unit of time. Nevertheless, in my opinion, conduction must always exist, especially if the glass is hot, although it may be negligible with very high frequencies.

Prof. Thomson states further that, from his point of view, I have misunderstood his statement about the limit

machines of 1 years ago, onstant current. All rmature reaction, and he output. The eco- ant current is to use the governor off the against racing only. If only quarter load on, it rly full steam, and wear- stant-pressure dynamo it cylinderful of steam be- expanded properly. To the engine, and then to over the difficulties you mmon proceeding with

have, however, one ad- s not realized. Synchron- series constant-current onstant speed, there is no g, as in the case of direct speed of engine is here ncy. Many people seem nson's paper that series it this is a false inference.

---

irrents of Very High y.

ESLA.

the note of Prof. Thom- f April 4, although I dis- rolonged controversy. I ave the last word, were render a reply from me

t whatever work Prof. currents of very high letter published in *The* ble, and even probable, some time before, and s meant in this general at quite a number of ex- ines and observed effects . Thomson. It is doubt- ence of any publication nomena described by me ne more so as very few e I did, and I would my- ad an advance of firm f the works of the most tain the results sought he direction, many will purpose I have shown

in regard to the experi-

ment that with a sufficiently high steady difference of potential enough current can be passed through the glass of a condenser with mercury coatings to light up a Geissler tube joined in series with the condenser. When the potential is alternating the condenser action comes in, and conduction becomes insignificant, and the more so the greater the rate of alternation or change per unit of time. Nevertheless, in my opinion, conduction must always exist, especially if the glass is hot, although it may be negligible with very high frequencies.

Prof. Thomson states further that, from his point of view, I have misunderstood his statement about the limit of audition. He says that 10,000 to 20,000 alternations correspond to 5,000 to 10,000 complete waves of sound. In my first reply to Prof. Thomson's remarks (in THE ELECTRICAL WORLD of March 21, 1891) I avoided pointing out directly that Prof. Thomson was mistaken, but now I see no way out of it. Prof. Thomson will pardon me if I call his attention to the fact he seems to disregard, namely, that 10,000 to 20,000 alternations of current in an arc—which was the subject under discussion—does not mean 5,000 to 10,000, but 10,000 to 20,000 *complete waves of sound*.

He says that I have adopted or suggested as the limit of audition 10,000 waves per second; but I have neither adopted nor suggested it. Prof. Thomson states that I have been working with 5,000 to 10,000 complete waves, while I have nowhere made any such statement. He says that this would be working below the limit of audition, and cites as an argument that at the Central High School in Philadelphia he has heard 20,000 waves per second; but he wholly overlooks a point on which I have dwelt at some length—namely, that the limit of audition of an arc is something entirely different from the limit of audition in general.

Prof. Thomson further states, in reply to some of my views expressed in regard to the constant current machines, that five or six years ago it occurred to him to try the construction of a dynamo for constant current, in which "the armature coils were of a highly efficient type, that is, of comparatively short wire length for the voltage and moving in a dense magnetic field." Exteriorly to the coils and to the field he had placed in the circuit of each coil an impedance coil which consisted of an iron core wound with a considerable length of wire and connected directly in circuit with the armature coil. He thus obtained, he thought, "the property of considerable self-induction along with efficient current generation." Prof. Thomson says he expected "that possibly the effects would be very much the same as those obtainable from the regularly constructed apparatus." But he was *disappointed*, he adds. With all the consideration due to Prof. Thomson I would say that to expect a good result from such a combination was rather sanguine. Earth is not farther from Heaven than this arrangement is

on the engine, and then to
et over the difficulties you
common proceeding with

nts have, however, one ad-
k is not realized. Synchron-
on series constant-current
constant speed, there is no
ning, as in the case of direct
t speed of engine is here
uency. Many people seem
okinson's paper that series
but this is a false inference.

Currents of Very High
-ncy.

. TESLA.

ent the note of Prof. Thom-
D of April 4, although I dis-
a prolonged controversy. I
n have the last word, were
nts render a reply from me

that whatever work Prof.
ting currents of very high
his letter published in *The*
ssible, and even probable,
ents some time before, and
was meant in this general
e that quite a number of ex-
achines and observed effects
Prof. Thomson. It is doubt-
absence of any publication
phenomena described by me
s. the more so as very few
uble I did, and I would my-
t had an advance of firm
dy of the works of the most
l obtain the results sought
ed the direction, many will
very purpose I have shown
hed.

vely in regard to the experi-
mp bulb and the filament
he cannot agree with me
the glass has anything to
served. He mentions the
descent lamp acts as a Ley-
duction through the glass
uld not occur." I think I
very few electricians will
ility of the condenser effect
that the rate at which the

of audition. He says that 10,000 to 20,000 alternations correspond to 5,000 to 10,000 complete waves of sound. In my first reply to Prof. Thomson's remarks (in THE ELECTRICAL WORLD of March 21, 1891) I avoided pointing out directly that Prof. Thomson was mistaken, but now I see no way out of it. Prof. Thomson will pardon me if I call his attention to the fact he seems to disregard, namely, that 10,000 to 20,000 alternations of current in an arc—which was the subject under discussion—does not mean 5,000 to 10,000, but 10,000 to 20,000 *complete waves of sound.*

He says that I have adopted or suggested as the limit of audition 10,000 waves per second; but I have neither adopted nor suggested it. Prof. Thomson states that I have been working with 5,000 to 10,000 complete waves, while I have nowhere made any such statement. He says that this would be working below the limit of audition, and cites as an argument that at the Central High School in Philadelphia he has heard 20,000 waves per second; but he wholly overlooks a point on which I have dwelt at some length—namely, that the limit of audition of an arc is something entirely different from the limit of audition in general.

Prof. Thomson further states, in reply to some of my views expressed in regard to the constant current machines, that five or six years ago it occurred to him to try the construction of a dynamo for constant current, in which "the armature coils were of a highly efficient type, that is, of comparatively short wire length for the voltage and moving in a dense magnetic field." Exteriorly to the coils and to the field he had placed in the circuit of each coil an impedance coil which consisted of an iron core wound with a considerable length of wire and connected directly in circuit with the armature coil. He thus obtained, he thought, "the property of considerable self-induction along with efficient current generation." Prof. Thomson says he expected "that possibly the effects would be very much the same as those obtainable from the regularly constructed apparatus." But he was *disappointed*, he adds. With all the consideration due to Prof. Thomson I would say that to expect a good result from such a combination was rather sanguine. Earth is not farther from Heaven than this arrangement is from one in which there would be a length of wire sufficient to give the same self-induction wound on the armature and utilized to produce useful E. M. F. instead of doing just the opposite, let alone the loss in the iron cores. But it is, of course, only fair to remember that this experiment was performed five or six years ago, when even the foremost electricians lacked the necessary information in these and other matters.

Prof. Thomson seems to think that self-induction wipes out the periodical undulations of current. Now self-induction does not produce any such affect, but, if anything,

it renders the undulations more pronounced. This is self-evident. Let us insert a self-induction coil in a circuit traversed by an undulating current and see what happens. During the period of the greatest rate of change when the current has a small value, the self-induction opposes more than during the time of the small rate of change and when the current is at or near its maximum value. The consequence is that with the same frequency the maximum value of the current becomes the greater, the greater the self-induction. As the sound in a telephone depends only on the maximum value it is clear that self-induction is the very thing required in a telephone circuit. The larger the self-induction the louder and clearer the speech, provided the same current is passed through the circuit. I have had ample opportunity to study this subject during my telephone experience of several years. As regards the fact that a self-induction coil in series with a telephone diminishes the loudness of the sound, Prof. Thomson seems to overlook that this effect is wholly due to the impedance of the coil, *i. e.*, to its virtue of diminishing the *current's strength*. But while the current's strength is diminished the undulation is rendered only more pronounced. Obviously, when comparisons are made they must be made with the same current.

In an arc machine such as that of Prof. Thomson's the effect is different. There one has to deal with a make and break. There are then two induced currents, one in the opposite the other in the same direction with the main current. If the function of the mechanism be the same, whether self-induction coil be present or not, the undulations could not possibly be wiped out. But Prof. Thomson seems likewise to forget that the effect is wholly due to the defect of the commutator; namely, the induced current of break—which is of the same direction with the main current and of great intensity when large self-induction is present—simply bridges the adjacent commutator segments, or if not entirely so, at least shortens the interval during which the circuit is open and thus reduces the undulation.

In regard to the improvement in the feeding of the lamps by vibration or undulations, Prof. Thomson expresses a decisive opinion. He now says that the vibrations *must* improve the feeding of a clockwork lamp. He says that I "contented myself by simply saying" that I cannot agree with him on that point.

Now, *saying it* is not the only thing I did. I have passed many a night watching a lamp feed, and I leave it to any skilled experimenter to investigate whether my

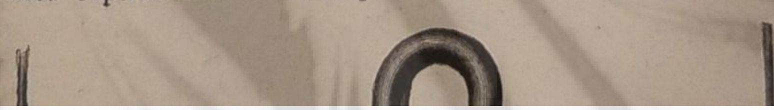
course to realize fully the
rent the release ought to
up and down movement,

In regard to the phys
says that in such a compa
as animal tissue the distri
erned by self-induction to
does not consider the tw
section pointed out by Si
sistance of the body to
assume either condenser a
the body.

The Stanl

As alternating current a
more general use it has go
evolution as has characteri
component parts of the sys
and more carefully, and mo
designed. It has taken so
the alternating dynamo to i
and the other necessary p
of the alternating system, t
is, the secondary generato
the transformer — has go
through somewhat the sa
slow process of evolution.
the early stages of the art
transformer was ineffic
and regulated badly. It
improperly designed and of
poorly built. Gradually
principles involved in its co
struction came to be und
stood, the parts were bet
proportioned to serve th
purpose, and a far better qu
ity of iron was used for the co

We give on the present pa
two cuts of the very la
type of transformer. It is m
ufactured by the Stanley M
Company from the design
who has become so widely
with the rise and developm
Many of the fundamental
fruits of Mr. Stanley's in



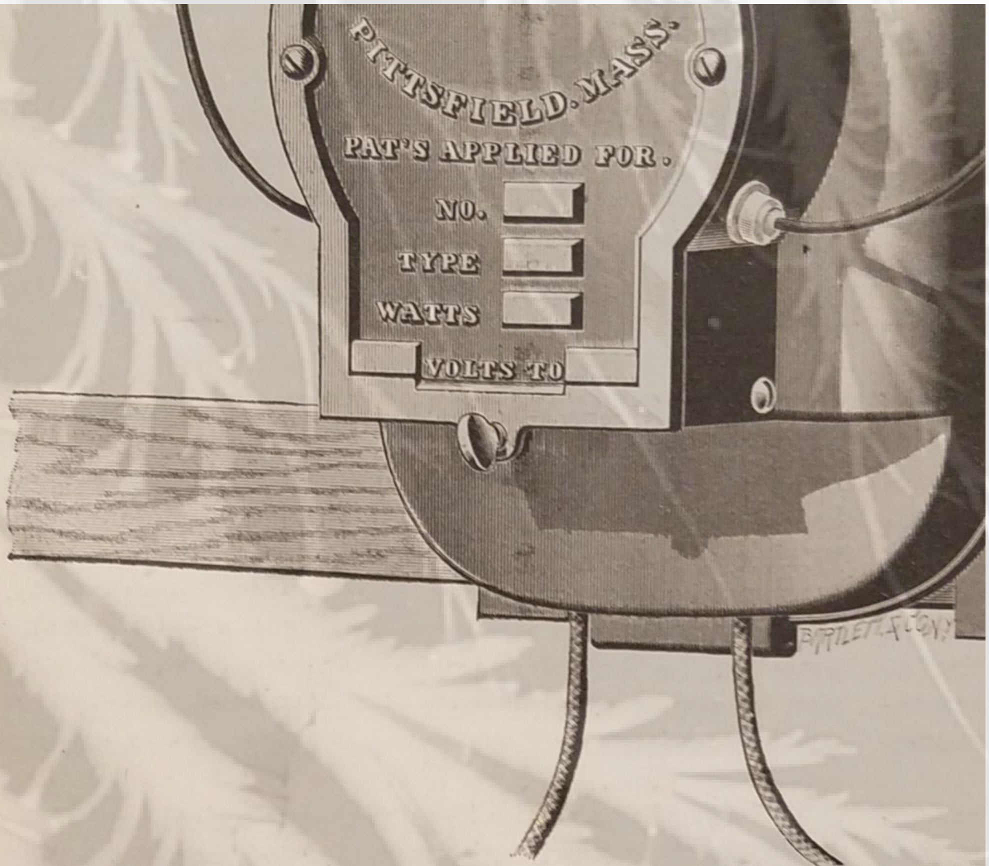


FIG. 1.—STANLEY ALTERNATING CURRENT TR

statements are correct. My opinion is that a clockwork lamp - that is, a lamp in which the descent of the carbon is regulated not by a clutch or friction mechanism, but by an escapement—cannot feed any more perfectly than tooth by tooth, which may be a movement of, say, one-sixty-fourth of an inch or less. Such a lamp will feed in nearly the same manner, whether the current be perfectly smooth or undulating, provided the conditions of the circuit are otherwise stable. If there is any advantage I think it would be in the use of a smooth current, for with an undulating current the lamp is likely to miss some time and feed by more than one tooth. But in a lamp in which the descent of the carbon is regulated by friction mechanism, an undulating current of the proper number of undulations per second will always give a better result. Of

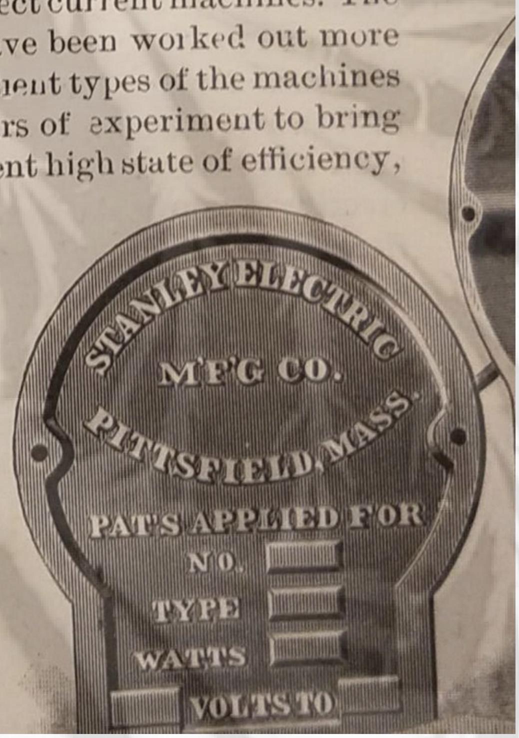
force in
rent bu
energy
These r
tested,
of wind
chance
and a s
the ins
cable p
safety.
the fus
notice.
a fusib
ondary

course to realize fully the benefits of the undulating current the release ought to be effected independently of the up and down movement, as I have pointed out before.

In regard to the physiological effects Prof. Thomson says that in such a comparatively poor conductive material as animal tissue the distribution of current cannot be governed by self-induction to any appreciable extent, but he does not consider the two-fold effect of the large cross-section pointed out by Sir William Thomson. As the resistance of the body to such currents is low, we must assume either condenser action or induction of currents in the body.

The Stanley Transformer.

As alternating current apparatus has come into more and more general use it has gone through the same stages of evolution as has characterized direct current machines. The component parts of the system have been worked out more and more carefully, and more efficient types of the machines designed. It has taken some years of experiment to bring the alternating dynamo to its present high state of efficiency, and the other necessary part of the alternating system, that is, the secondary generator—the transformer — has gone through somewhat the same slow process of evolution. In the early stages of the art the transformer was inefficient and regulated badly. It was improperly designed and often poorly built. Gradually the principles involved in its con-



Tesla Speech for the Institute of Immigrant Welfare

Hotel Biltmore, May 12, 1938

Tesla not present to receive honorary citation.

April or May, 1939

From: Dr. Nikola Tesla

Mr. Chairman,
Members of the Institute of Immigrant Welfare,
Ladies and Gentlemen:

I can not find words to express adequately my keen regret
for being unable to receive, in person, the high distinction which
the Institute of Immigrant Welfare has conferred upon me. Although
my recovery from injuries sustained in an automobile accident six
months ago is almost complete, I do not feel equal to the task of
appearing in public and meeting the obligations which this would
impose upon me.

My coming to this country was a great adventure -- every
detail of which is still vivid in my memory. Early in 1884, while
employed by a French Company in Paris, France, I made important
improvements in dynamos and motors and was engaged by the Edison
interests in New York to design and construct similar machines for
them. It had been the height of my ambition and my most ardent wish
to come in contact with Edison and see America. Accordingly, I
undertook the voyage and after losing my money and tickets and
passing through a series of mishaps, including a mutiny in which
I nearly lost my life, I landed on these blessed shores with four
cents in my pocket. My first intention was to look up a close
American friend before going to the Edison establishment. On my
way uptown I cam to a small machine shop in which the foreman was
trying to repair an electric machine of European make. He had just
given up the task as hopeless and I undertook to put it in order
without a thought of any compensation. It was not easy but I finally
had it in perfect running condition. I was astonished when he gave
me twenty dollars and wished that I had come to America years be-
fore. The next day I was thrilled to the marrow by meeting Edison
who began my American education right then and there. I wanted to
have my shoes shined, something I considered below my dignity.
Edison said: "Tesla, you will shine the shoes yourself and like it.
He impressed me tremendously. I shined my shoes and liked it.

I began the work for which I was engaged immediately and after
nine months of strenuous effort I fulfilled my contract rigorously.
The manager had promised me fifty thousand dollars but when I de-
manded payment, he merely laughed. "You are still a Parisian,"
remarked Edison, "when you become a full-fledged American you will
appreciate an American joke." I felt deeply hurt as I had expected
to use the money in the development of my alternating system and
when some people proposed to form a company under my name, I accepted
eargerly. Here as the opportunity I had vainly sought for years but
my new friends were adamant in their resolve not to have anything
to do with the worthless alternating currents which Edison condemned
as deadly. They desired an arclight system and I had to comply
with their request though the delay of my cherished plans was agon-
izing. In one year of day and night application, I managed to per-
fect the system which was adopted for lighting the city and some
factories in the neighborhood. Then came the hardest blow I ever
received. Through some local influences, I was forced out of the
company losing not only all my interest but also my reputation as
engineer and inventor. After that I lived through a year of terri-
ble heartaches and bitter tears, my suffering being intensified by

material want. Very often I was compelled to work as a laborer and my high education in various branches of science, mechanics and literature seemed to me like a mockery. Finally, I had the good fortune of meeting two capable and honest men who listened to me and came to my assistance. They organized a company, provided a laboratory and gave me a modest but sure financial support. I perfected my motors quickly having nothing else to do except to carry out plans I had formed years before. My inventions proved a success and attracted the attention of George Westinghouse. He was, in my opinion, the only man on this globe who could take my alternating system under the circumstances then existing and win the battle against prejudice and money power. He was a pioneer of imposing stature, one of the world's true noblemen of whom America may well be proud and to whom humanity owes an immense debt of gratitude.

I have to add that in all my troubles I did not neglect to declare my intention of becoming a citizen of this glorious country and in due course I secured my papers making me a proud and happy man.

Nikola Tesla

5-28
April or May, 1938

From: Dr. Nikola Tesla

Mr. Chairman,
Members of the Institute of Immigrant Welfare,
Ladies and Gentlemen:

I can not find words to express adequately my keen regret for being unable to receive, in person, the high distinction which the Institute of Immigrant Welfare has conferred upon me. Although my recovery from injuries sustained in an automobile accident six months ago is almost complete, I do not feel equal to the task of appearing in public and meeting the obligations which this would impose upon me.

My coming to this country was a great adventure -- every detail of which is still vivid in my memory. Early in 1884, while employed by a French Company in Paris, France, I made important improvements in dynamos and motors and was engaged by the Edison interests in New York to design and construct similar machines for them. It had been the height of my ambition and my most ardent wish to come in contact with Edison and see America. Accordingly, I undertook the voyage and after losing my money and tickets and passing through a series of mishaps, including a mutiny in which I nearly lost my life, I landed on these blessed shores with four cents in my pocket. My first intention was to look up a close American friend before going to the Edison establishment. On my way uptown I cam to a small machine shop in which the foreman was trying to repair an electric machine of European make. He had just given up the task as hopeless and I undertook to put it in order without a thought of any compensation. It was not easy but I finally had it in perfect running condition. I was astonished when he gave me twenty dollars and wished that I had come to America years before. The next day I was thrilled to the marrow by meeting Edison who began my American education right then and there. I wanted to have my shoes shined, something I considered below my dignity. Edison said: "Tesla, you will shine the shoes yourself and like it. He impressed me tremendously. I shined my shoes and liked it.

I began the work for which I was engaged immediately and after nine months of strenuous effort I fulfilled my contract rigorously. The manager had promised me fifty thousand dollars but when I demanded payment, he merely laughed. "You are still a Parisian," remarked Edison, "when you become a full-fledged American you will appreciate an American joke." I felt deeply hurt as I had expected to use the money in the development of my alternating system and when some people proposed to form a company under my name, I accepted eargerly. Here as the opportunity I had vainly sought for years but my new friends were adamant in their resolve not to have anything to do with the worthless alternating currents which Edison condemned as deadly. They desired an arclight system and I had to comply with their request though the delay of my cherished plans was agonizing. In one year of day and night application, I managed to perfect the system which was adopted for lighting the city and some factories in the neighborhood. Then came the hardest blow I ever received. Through some local influences, I was forced out of the company losing not only all my interest but also my reputation as engineer and inventor. After that I lived through a year of terrible heartaches and bitter tears, my suffering being intensified by

material want. Very often I was compelled to work as a laborer and my high education in various branches of science, mechanics and literature seemed to me like a mockery. Finally, I had the good fortune of meeting two capable and honest men who listened to me and came to my assistance. They organized a company, provided a laboratory and gave me a modest but sure financial support. I perfected my motors quickly having nothing else to do except to carry out plans I had formed years before. My inventions proved a success and attracted the attention of George Westinghouse. He was, in my opinion, the only man on this globe who could take my alternating system under the circumstances then existing and win the battle against prejudice and money power. He was a pioneer of imposing stature, one of the world's true noblemen of whom America may well be proud and to whom humanity owes an immense debt of gratitude.

I have to add that in all my troubles I did not neglect to declare my intention of becoming a citizen of this glorious country and in due course I secured my papers making me a proud and happy man.

Nikola Tesla

MSS 481

From: Dr. Nikola Tesla

Mr. Chairman,
Members of the Institute of Immigrant Welfare,
Ladies and Gentlemen:

I can not find words to express adequately my keen regret for being unable to receive, in person, the high distinction which the Institute of Immigrant Welfare has conferred upon me. Although my recovery from injuries sustained in an automobile accident six months ago is almost complete, I do not feel equal to the task of appearing in public and meeting the obligations which this would impose upon me.

My coming to this country was a great adventure -- every detail of which is still vivid in my memory. Early in 1884, while employed by a French Company in Paris, France, I made important improvements in dynamos and motors and was engaged by the Edison interests in New York to design and construct similar machines for them. It had been the height of my ambition and my most ardent wish to come in contact with Edison and see America. Accordingly, I undertook the voyage and after losing my money and tickets and passing through a series of mishaps, including a mutiny in which I nearly lost my life, I landed on these blessed shores with four cents in my pocket. My first intention was to look up a close American friend before going to the Edison establishment. On my way uptown I cam to a small machine shop in which the foreman was trying to repair an electric machine of European make. He had just given up the task as hopeless and I undertook to put it in order without a thought of any compensation. It was not easy but I finally had it in perfect running condition. I was astonished when he gave me twenty dollars and wished that I had come to America years before. The next day I was thrilled to the marrow by meeting Edison who began my American education right then and there. I wanted to have my shoes shined, something I considered below my dignity. Edison said: "Tesla, you will shine the shoes yourself and like it. He impressed me tremendously. I shined my shoes and liked it.

I began the work for which I was engaged immediately and after nine months of strenuous effort I fulfilled my contract rigorously. The manager had promised me fifty thousand dollars but when I demanded payment, he merely laughed. "You are still a Parisian," remarked Edison, "when you become a full-fledged American you will appreciate an American joke." I felt deeply hurt as I had expected to use the money in the development of my alternating system and when some people proposed to form a company under my name, I accepted eargerly. Here as the opportunity I had vainly sought for years but my new friends were adamant in their resolve not to have anything to do with the worthless alternating currents which Edison condemned as deadly. They desired an arclight system and I had to comply with their request though the delay of my cherished plans was agonizing. In one year of day and night application, I managed to perfect the system which was adopted for lighting the city and some factories in the neighborhood. Then came the hardest blow I ever received. Through some local influences, I was forced out of the company losing not only all my interest but also my reputation as engineer and inventor. After that I lived through a year of terrible heartaches and bitter tears, my suffering being intensified by

material want. Very often I was compelled to work as a laborer and my high education in various branches of science, mechanics and literature seemed to me like a mockery. Finally, I had the good fortune of meeting two capable and honest men who listened to me and came to my assistance. They organized a company, provided a laboratory and gave me a modest but sure financial support. I perfected my motors quickly having nothing else to do except to carry out plans I had formed years before. My inventions proved a success and attracted the attention of George Westinghouse. He was, in my opinion, the only man on this globe who could take my alternating system under the circumstances then existing and win the battle against prejudice and money power. He was a pioneer of imposing stature, one of the world's true noblemen of whom America may well be proud and to whom humanity owes an immense debt of gratitude.

I have to add that in all my troubles I did not neglect to declare my intention of becoming a citizen of this glorious country and in due course I secured my papers making me a proud and happy man.

Nikola Tesla